No child is born into the world with a moral sense. Moral concepts are inculcated. Moral sense is developed. Children are what we make them. If they assume obligations and respect the rights of others in response to a moral concept, no command to do so is necessary. When the discharge of an obligation is gratifying and the performance of a duty is a joy, proper foundation is laid for a decent relationship towards oneself and one's fellows.—JACOB PANKEN.

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SCHOOL SCIENCE AND MATHEMATICS

VOL. XLV OCTOBER, 1945 WHOLE NO. 396

OUR 1945 CONVENTION PROGRAM

The war is over, but certain of its lessons must not be forgotten. Among these are the supreme values of education, particularly the values of science and mathematics education. They were indispensable in war, and they are no less vital to the realization of our destiny in times of peace. Central Association is presenting a program that will help us to renew our faith in the values of the subjects we teach and help us to carry these values into our teaching. Just to illustrate this fact, we here present a list of a few of the speakers, and a list of a few of the subjects to be discussed. Turn to your Yearbook in order to learn of the complete program offerings. The Yearbook should reach you before November 1; if it does not do so, please write Mrs. Geraldine R. Johnson, Washington High School, Indianapolis, and ask for your copy. Please plan to be with us at Chicago. The November issue of SCHOOL SCIENCE AND MATHEMATICS will give you last minute instructions about travel.

SOME OF THE SPEAKERS

H. C. Christofferson, past President of The National Council of Teachers of Mathematics; author of Geometry Professionalized for Teachers.

O. W. Eshbach, Dean of The Technological Institute of Northwestern University.

William Betz, specialist in mathematics in the Rochester, New York, public schools; author of a number of text books in mathematics; member of the Commission on Post War Plans.

V. S. Peterson, member of the Public Relations staff of Du Pont, and widely known lecturer.

Anton J. Carlson, eminent scientist and dramatic teacher of science.

Clyde V. Arnspiger, educational consultant to Encyclopaedia Britannica Films.

H. B. Hass, head of the Department of Chemistry, Purdue University, and popular lecturer on chemistry applied to the affairs of daily life.

Clyde V. Kohn, eminent geographer of Northwestern University.

Guy T. Buswell, The University of Chicago; arithmetic specialist.

H. A. Lyon, of The Ferguson Company. The Ferguson Company is revolutionizing farm machinery.

Bertha Parker, The University of Chicago, specialist in elementary science.

Some Program Highlights

Whither Science and Mathematics? Do we know where we are going, or where we should go?

War Research and Post War Living. What will war research have to do with how we ride, or eat, or sleep, or are entertained in the years just ahead?

Use Of the Film in Instruction. The United States used films on a lavish scale in its program of instruction of inductees. What can we learn from this experience?

Food and Nutrition Problems. When millions of people starve to death, and other millions have their diets radically altered, what do we learn about food and its effects?

Teaching Pupils to Think. Is thinking one of the most desirable outcomes of the education program? How can this outcome be secured?

Objectives of Science Teaching. Do we know clearly what they are? How long has it been since we reevaluated them?

Geography in The Air Age. Will all of our geography thinking, teaching and learning have to be made over?

Problem Solving in Arithmetic. Is there a way to approach this difficulty so as to get better results?

Pattern for Prosperity. With our natural resources depleted, with debts beyond our comprehension, with millions unemployed, with the world to feed, is there a pattern for prosperity?

Mathematics in a World at Peace. Will peace time mathematics be radically different from war time mathematics?

Cooperative Education. What is the ideal condition for learning? A teacher to give instruction and a pupil to receive it? Two learners finding out facts and principles together?

The Problem of Reading in Mathematics. Does the problem exist? Who should solve it, the teacher of reading or the teacher of mathematics? How can the problem be solved?

A Science Program for the Elementary Schools? Do you know of a large school system that has a *program* of elementary science? Do you know two such systems, or two educational leaders that agree on what such a program should be? Do you know what should constitute the program in your school?

New Drug Research. Vitamins, minerals, cures, penicillin, synthetic quinine, insulin, etc., etc. Are they all that we have come to believe them to be? What are the dangers of their use? How are they made? What is their future?

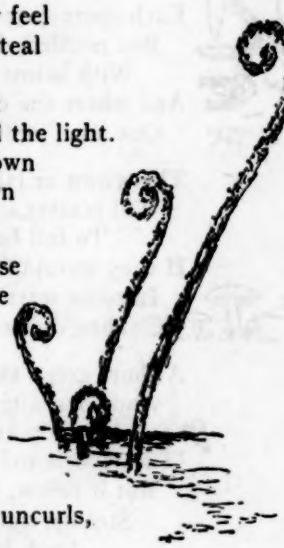
The questions raised in connection with the subjects listed above are those of an ordinary teacher as he reads the program, not necessarily those to be raised and answered by our speakers. The discussion periods provided on the various programs will make it possible for you and me to raise any of these questions not discussed by speakers in their formal presentations of their papers.

THE FERN—A SCIENCE FANTASY

ELIZABETH STOUGHTON RAWLS
Shortridge High School, Indianapolis, Ind.

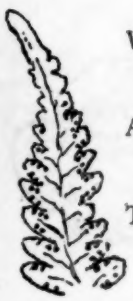
My lovely leaves are large and few,
I wonder if you ever knew
Of how they grew?

You'd scarcely guess how shy they feel
When first into the world they steal
To look around.
A great adventure, wondrous sight
This cautious reaching toward the light.
For rolled up tight and cuddled down
They first appear upon the crown
Of Mother fern.



They roll a way, then seem to pause
To stop and look around because
It's all so strange.
A lovely curving coil on wing
A coil that is about to spring
A gay surprise on everything
—That's wise enough to watch.

A tiny leaflet first unfurls
Then more and more green lace uncurls,
A plumy frond.
With summer winds they'll lilt and swerve
They know they form a lovely curve,
The line of grace.
And when they've grown to their full height
And taught men's eyes a new delight,
Like songs on air,
The leaves that know a fuller share
Of sun and wind and shadow fair
May reproduce.



For many a leaflet fondly yearns
To start in life some little ferns
Their very own.

A close inspection will disclose
A line of small brown dots, in rows—
Like buttons sewed, on fairy clothes,
Now here, now there—
Some have a sort of rolled up hem,

Some, like an elfin diadem
Have gay festoons
Of crescent moons—
The maidenhair.

With fairy microscopic eye
Behind a curtain brown, we'd spy
Queer clumps of clubs.

Each spore-case like a head appears
But muffled clear up to the ears
With helmet brown and spring-like crown.
And where the case should have a face
One day 'twill make a wild grimace

This yawn or laugh or cough or sneeze
Will scatter spores all down the breeze
To fall below.
If they should find a cozy home
In some warm nook of moistened loam
They'd stretch and grow.

A short green thread, and then a spear
And soon a tiny heart is here
—A drop across—
'Tis smooth and green along the top
But if below, your head you'd pop,
Strange sights would make your breathing stop—
Look here—
How Queer—

There at one end are rhizoid ropes
That hold it fast to mossy slopes.
They're pipe-lines too.
At this same spot there can be found
A glassy looking sort of mound,
Sperms to surround.
The other end has turrets tall,
They're tipped and tilted one and all
Down toward the ground.

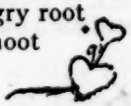
The Sperm with many a swirl and swish
Can swim as well as any fish
This pond of dew
('Twould look but like a drop to you).
He's hunting for the turret gate,
He seeks to join his little mate,
The treasured Egg.

She's deeply hidden, you will learn
Within the green-heart of the fern
Protected by this castled turn
And deep canal.

When Sperm locates the Egg he'd chose,
Then strength with strength, the two cells fuse—
Their own identity to lose,
And live as one.

Now here a miracle is clear
New life begun.

You look away, and back, and lo,
A baby fern begins to show
In green-heart's arms,—
A creeping stem with hungry root
A soft uncurling little shoot
All—very small.



Ah what a cunning little toy
A thing to fill a heart with joy,
Of girl or boy.

'Twill grow and grow, till when you're big
You may discover it and dig
And take it home
And plant it by your garden gate
Where you may watch from spring till late,
Your little Fern.

SNAKE TALES

Throughout the history of man in the world, snakes have been reviled; strange beliefs have risen and still linger around them. There is one which says that the milk snake can milk cows; but no snake is able to do this. Another concerns the mysterious Joint Snake, usually the legless lizard, which is said to fly into pieces when struck with a stick, and shortly afterward unites and lives. It is said, too, that a rattlesnake may commit suicide when tortured, and that his age can be told by the number of rattles, but these beliefs also are untrue.—*The Living Museum.*

TWO LABORATORY MOTOR VARIANTS

ELBERT C. WEAVER
Phillips Academy, Andover, Mass.

Some boys with an experimental turn of mind recently devised a couple of interesting ways to use the small motors so common in many laboratories. The type they worked with is the St. Louis Motor, Cenco Improved Design, No. 79943 with a No. 79947 electromagnet attachment.

1. A SELF-STARTING REPULSION MOTOR

A St. Louis D.C. electric motor can be made to act as a self-starting repulsion motor by short-circuiting its brushes with an external wire. A 10-volt alternating e.m.f. is applied to the U-shaped field magnet. The brushes must be adjusted until the motor operates satisfactorily.

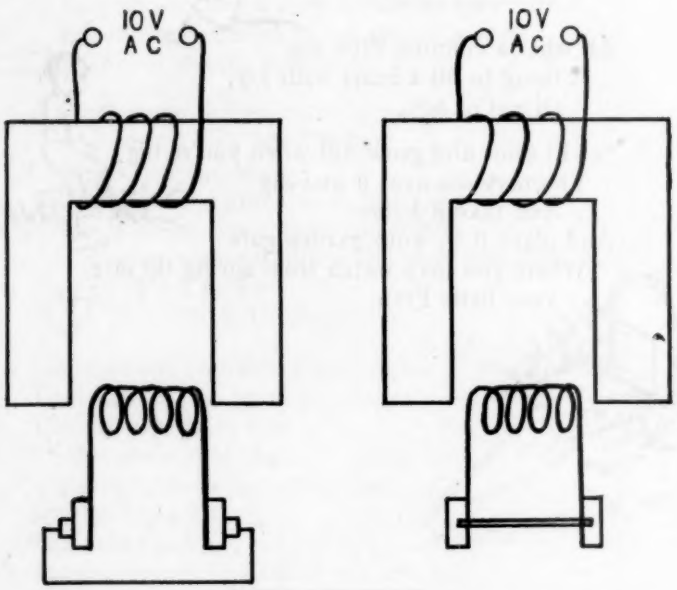


FIG. 1. At left, repulsion motor; at right, induction motor.

2. AN INDUCTION MOTOR

The St. Louis motor can also be made to operate as an induction motor. Its brushes are removed and a bare copper wire is wrapped around the commutator of the D.C. rotor. This motor must be started by spinning the rotor while a 10-volt alternating e.m.f. is applied to the field.

COMBINATIONS INVOLVING SIMILAR OBJECTS

BROTHER U. ALFRED
Mont La Salle, Napa, California

The number of combinations of n things taken r at a time is given very simply by the formula:

$$_nC_r = \frac{n!}{r!(n-r)!}.$$

But there does not seem to be any such general formula in the corresponding case when some of the objects are similar. Three methods are herewith discussed for attaining a solution.

METHOD 1. INDIVIDUAL ENUMERATION

In a very elementary case, one may proceed to display all possible combinations and thus enumerate them. Thus, if we have six objects, three of which are alike, and we wish to determine the number of combinations of these objects taken three at a time, we could let the objects be designated by letters *aaabcd*. Then the required combinations are: *aaa*, *aab*, *aac*, *aad*, *abc*, *abd*, *acd*, *bcd*, or eight in all. But it is readily perceived that this method would run into an impossible amount of work, as soon as we attack more difficult cases.

METHOD 2. PARTITION METHOD

Before displaying a second method, a bit of notation is in order. If we have thirty-seven objects, seven of which are alike, another six alike, a second group of six similar, a group of four, a second group of four, a group of three, of two, and finally five individual dissimilar objects, this can be represented by 766443211111. (If numbers 10 or greater were present, these could be set off by commas). This is a partitition notation, being one partition of the number 37.

Suppose we have 40 objects 65444333221111, according to the system just described. We wish to determine the number of combinations of these objects taken four at a time. We first write down all the partitions of 4:

4 to stand for groups of 4 similar objects
31 groups of three similar and one dissimilar object
22 two groups of two similar objects each

211 one group of two similar objects and two dissimilar objects

1111 four dissimilar objects.

We next determine the number of ways in which each such partition may be secured from the given group of objects 65444333221111. Obviously, there are five types of object which can have four the same namely those represented by 65444.

Three similar objects may be taken in eight different ways (65444333) and thereafter one object may be chosen in 13 different ways, since there are 14 types of object in all. Thus the total number of combinations of the 31 type is eight times thirteen or 104.

There are ten groups with two or more objects. Hence the combinations of the 22 variety will be the number of combinations of ten things taken two at a time or 45.

For 211, the "2" group may be chosen in 10 different ways and from the remaining thirteen types, two dissimilar objects may be chosen in $13 \cdot 12/1 \cdot 2 = 78$ ways. Hence there are 10 times 78 or 780 combinations of this variety.

Finally, the number of combinations of fourteen things taken four at a time yields 1001, the answer for 1111. Hence, in all we have the following table:

Type	*No. of Combinations*
4	5
31	104
22	45
211	780
1111	1001
	1935

(Solution time: $1\frac{1}{2}$ min.)

This method is very useful and straightforward for small numbers, such as 4 in the above instance. But for larger groups, the work increases in magnitude very rapidly. Given, for example, the twenty-five objects 55432111111, required to determine the number of combinations taken 9 at a time. The partitions with the corresponding number of combinations for each is as follows:

Type	*No. of Combinations*
54	4
531	54
522	12
5211	288
51111	420
441	27
432	27
4311	324
4221	144
42111	1008
411111	756
333	4
3321	144
33111	504
3222	16
32211	672
321111	2016
3111111	840
22221	35
222111	560
2211111	1260
21111111	600
111111111	55
	9770

Time: 10 minutes. Additional time required for checking.

Another difficulty with this method is that if a mistake is made the only check seems to be to go over the work directly which is very tedious and sometimes apparently, one makes the same mistake over and over again. Thus there is no independent check to assure one he has the correct answer.

If, however, this answer can be checked by another method (e.g., the one mentioned below), this enumeration becomes useful, especially in calculating the number of permutations of n things taken r at a time when some of them are similar. For example, suppose we wish to know the permutations of 17 things (44321111) taken 6 at a time.

We first determine the different types of combination and the number of each as above. For example, for the type 3111, there are 105 cases. But the permutations of a combination of this type will be given by:

$$\frac{6!}{3!}=120.$$

Hence we have 105 times 120 or 12600 permutations from this source. Proceeding in a similar manner for all other combination types and adding the result the answer is obtained. The following table displays the results.

Type	*No. of Combinations*	*Permutations per Combination*	*Total Permutations*
42	6	15	90
411	42	30	1260
33	3	20	60
321	54	60	3240
3111	105	120	12600
222	4	90	360
2211	90	180	16200
21111	140	360	50400
111111	28	720	20160
			104370

Method 3. Multiplication Method

In principle, this method builds up from the number of combinations in smaller assemblages to the number in larger groups by a series of steps. Suppose we know the combinations of n objects taken in all different ways. If we add three similar objects of another kind and wish to determine the number of combinations in the new assemblage taken r at a time, we need but add the numbers for n objects taken r, $r-1$, $r-2$, and $r-3$ at a time, corresponding to adding 0, 1, 2, or 3 new objects.

Now, if the original number of combinations of objects taken s at a time is placed as a coefficient of x to the s power and a polynomial thus formed, it becomes obvious that by multiplying this polynomial by x^3+x^2+x+1, we obtain a new polynomial whose coefficients are the number of combinations of $n+3$ objects taken r at a time (this being the coefficient of x^r).

We may look upon the process, therefore, as one of adding a series of successive coefficients or of multiplying polynomials. Using the latter approach, we can formulate a method of compressed multiplication. Thus to multiply x^2+x+1 by $x^4+4x^3+6x^2+4x+1$, we proceed as follows. Write the coefficients in groups of three (since we are multiplying by three terms):

$$\begin{array}{lll} 1 & 4 & 6 \\ 4 & 1 & \end{array}$$

It can readily be verified by referring to the actual multiplicative process that the following method gives the correct coefficients of the product polynomial. We start with 1 in the first line: that is the first coefficient in the product. The second coefficient is 1 plus 4 in the first line or 5. The third is 5 plus 6 or 11. The fourth is 11 plus 4 in the second line minus 1 in the first line or 14. The fifth is 14 plus 1 in the second line minus 4 in the first line or 11. The sixth is 11 plus 0 in the second line minus 6 in the first or 5. The seventh is 5 plus zero in the third line minus 4 in the second line or 1. This takes a long time to write out, but in reality it is a very simple calculation. Thus the product polynomial is

$$x^6+5x^5+11x^4+14x^3+11x^2+5x+1$$

as may be readily verified.

Now suppose one wishes to solve the problem of determining the number of combinations of 17 things (44321111) taken 6 at a time. We can start with the expansion of $(x+1)^4$ whose coefficients are the number of combinations of four dissimilar objects taken 4, 3, 2, 1 at a time respectively. This takes care of 1111. The next group of 2 corresponds to a factor x^2+x+1. Hence we group the coefficients of the above polynomial: $x^4+4x^3+6x^2+4x+1$ in threes and proceed to multiply in the manner previously mentioned. These resulting coefficients would be grouped in four's since the next set of similar objects has 3 in it corresponding to a multiplication by x^3+x^2+x+1. Proceeding similarly for the two groups of 4 objects, we have the arrangement shown on the following page.

All the terms in the successive polynomials have been written out. This was not necessary for the given problem which re-

	1	4	6		
	4	1			
2	1	5	11	14	
	11	5	1		
3	1	6	17	31	41
	41	31	17	6	1
4	1	7	24	55	96
	136	161	161	136	96
	55	24	7	1	
4	1	8	32	87	183
	318	472	609	690	690
	609	472	318	183	87
	32	8	1		

quired the number of combinations taken six at a time. Actually, only the first seven are needed, since the seventh term gives the number of combinations taken $n-6$ at a time, which is the same as the number taken 6 at a time. Thus the answer is seen to be 472.

There are two checks available in this method. The first is the symmetry at each step if carried out completely. The second may be derived by substituting 1 for x in the polynomials multiplied implicitly. Thus starting with 2 to the fourth or 16, we multiply by 3 by 4 by 5 by 5 to obtain 4800. This should be the sum of the coefficients in the final product. Furthermore, each product may be tested in this manner if we are looking for an error.

Another advantage of the method is that it is possible to obtain all the combinations in one process. Harking back to Method 2, we see, for example, that one answer was obtained in 19 minutes. Suppose we had to find all the combinations taken in every possible way!

The advantages of this third method are: (1) Greater speed in general. The only exception would be the case in which one wanted to find the number of combinations 2, 3, 4, or the like at a time; (2) Obtaining all the combinations in one series of operations; (3) A double check on the work.

On the other hand (as far as the author knows), these gross

figures do not lend themselves to permutation calculations. It is here that the second method would be useful. But due to the danger of error, it would be well to check it by this third method as regards the total number of combinations in the case in question.

OVER MEXICAN VOLCANO IN HELICOPTER

CHRISTINA BUECHNER
Science Service Staff Writer

As the first woman to fly in a helicopter over the Mexican volcano Paricutin near here, this correspondent had the feeling of viewing very closely a natural drama from a grandstand seat in a show window.

There was no feeling of danger in sitting in the transparent bulge of the cockpit while Flight Officer Roy P. Beer buzzed the crater in the Army's hovering helicopter R6A, one of the many flights made during two weeks of exploration that simultaneously tested this unusual craft's performance at high altitude and explored the erupting volcano. There was so much of interest to see that there was no time for feeling afraid.

Our take-off was from the helicopter camp just beyond where the lava ceased to flow some months ago after engulfing the little town of San Juan Parangaricutiro, leaving only the steeple of the church in sight. The helicopter needs only a little clear space to land and take off. From this 7,200 feet above sea level, the helicopter rose to 1,500 feet above the crater which rises a thousand feet above what was merely a cornfield from which the volcano burst forth 2½ years ago.

This was considered by the officers of the Air Technical Service Command of Wright Field, Ohio, in charge of the aeronautical aspects of the expedition, as very satisfactory flying for a helicopter that was built to operate at lower altitudes.

Idling over the volcano and its lava beds, the helicopter has carried the American and Mexican volcanologists on flights that in several cases allowed prompt observation and study of new volcanic activity that would have ceased before the areas could have been reached tortuously on foot. Several landings were made near such newly active areas and the geologists were able to make inspections in a few minutes that otherwise would have required many hours of climbing.

Around the jagged and sometimes still warm lava beds the convection currents are strong, the air is bumpy and flight is turbulent.

Because of the rainy season less than half of the daylight hours have been suitable for observations during approximately two weeks that the expedition has been at the volcano. There have been more than 30 hours of flying with about 60 flights. Forty of these gave the geologists close views of the crater, and many times the pilot dropped down to within 300 feet of the crater's rim.

The scientists who did most of the observing were: Dr. Ezequiel Ordonez, leading Mexican geologist, Dr. L. C. Graton of Harvard, and Dr. W. F. Foshag of the U. S. Geological Survey and U. S. National Museum.

ESTIMATING THE RATE OF TRANSPORTATION OF ROCK MATERIAL BY A CREEK AS A PROJECT IN EARTH SCIENCE*

VICTOR E. SCHMIDT
Central School, Cobleskill, New York

One of the most worthwhile experiences which may be had by high school pupils in connection with the study of erosion is to estimate the rate at which a local creek removes rock material in solution and in suspension. This project gives the pupils first-hand evidence of the rate of erosion in their home area, evidence which is far more meaningful to them than textbook statements concerning some far-off river. It does much toward acquainting them with the methods of science if they themselves plan and carry out the work and then subject their methods and findings to critical analysis. It provides an often-needed practical review of simple mathematics. Furthermore, it seems to intrigue most pupils to the point where they *want* to do it.

Cobleskill Creek is a typical small stream of east-central New York. Near our school it is about 70 feet in width and normally averages about a foot in depth. Its gradient in this area is between 20 and 25 feet per mile. The flow is consequently fairly slow, but not sluggish. The water is generally quite clear, and becomes appreciably muddy only during times of high water.

The area drained by the creek and its tributaries above Cobleskill approximates 95 square miles. The region is hilly and constitutes a part of what may be considered the northern foothills of the Catskill Mountains. The higher hills attain elevations between 2000 and 2500 feet, while the creek at Cobleskill is about 900 feet above sea level. The greater part of the drainage basin is underlain by shale and sandstone, with some limestone in the headwater region of West Creek and in the lower part of the Cobleskill valley. With the exception of infrequent cliffs and banks, the bed rock is veneered with glacial till and, in the larger valleys, with glacial lake deposits of clay, silt and sand. Near Cobleskill the creek bed consists largely of gravel. Farther upstream, however, the creek and its tributaries flow variously on gravel, sand, silt, clay and their mixtures. Nearly

* The project described was carried out during three consecutive school years. The pupils in the classes were mostly juniors and seniors in high school, with an occasional sophomore.

The course in Earth Science in this State is a modified physical geography course. It may be taken by pupils at any time after they have taken and passed the 9th grade course in general science.

half of the drainage area consists of crop land. The rest is devoted mainly to pasture, with some woodland on the higher hills.

Before he reads farther, the reader is encouraged to hazard guesses as to the weight of sediment in suspension and of minerals in solution carried away each day by a creek of this sort, and then to compare his figures with the estimates given on the following pages.

Determining the Rate of Removal of Dissolved Minerals

During a field trip to the creek on October 14, 1942 a discussion arose as to the effectiveness of such a comparatively small, slow and clear stream in the removal of rock waste. The pupils seemed so interested in the matter that the rest of the planned work was postponed, and they proceeded to attempt an estimate of the rate at which the creek was transporting rock material. Since the stream level was fairly low at the time and the water evidently carrying little, if any, sediment in suspension, they decided to confine their efforts to estimating the rate of removal of mineral material in solution.

They paced off a distance of 100 feet along the creek where its course was straight and its width, depth and velocity fairly uniform, and estimated the average width and depth. Then they found the average time required for floating sticks to be carried the 100 feet. Next they obtained a sample of the water in a gallon jug.

Later, in the laboratory, the approximate volume of water in the 100-foot stretch of the creek at a given instant was found by multiplying the length, average width and average depth. The number of times this volume was being replaced in a day was calculated by dividing the number of seconds in a day by the average number of seconds required for the floating sticks to be carried the 100 feet and multiplying the quotient by a correction factor of 0.8.[1] The approximate rate of flow, in cubic

[1] This is necessary because the average velocity of the water in a stream is less than that of the surface water. An accurate determination of this average velocity necessitates the use of a current meter and a rather involved technique. A rough estimate, however, may be obtained by multiplying the average surface velocity by a correction factor.

Cristiansen, p. 12, states that, while experiments have shown this factor to vary from 0.55 to nearly 1.0, a value of 0.85 is ordinarily used for rough estimation. According to Baker and Conkling, p. 147, the coefficient ordinarily ranges from somewhat under 0.85 to a little over 0.95, but may fall as low as 0.70 in shallow and swift streams with rough bottoms. A simple rule, probably sufficiently accurate for this purpose, is that of Palmer, p. 31, who suggests that a factor of 0.9 be used for streams with smooth bottoms and 0.8 for streams with rough bottoms.

feet per day, was determined by multiplying the number of cubic feet of water in the stretch of the creek at a given instant by the number of times this volume was being replaced in a day.

The sample of water was filtered and then boiled off in a new beaker, previously weighed to the nearest hundredth of a gram. The boiling of the final few milliliters was done over a water bath. A thin brownish deposit of scale remained. Its weight was determined by weighing the beaker again and subtracting the weight of the empty beaker.

Finally, the rate of removal of dissolved minerals, in tons per day, was calculated by multiplying the rate of flow, in cubic feet per day, by the mineral content of the water, in grams per cubic foot, and dividing the product by the number of grams in a ton. Even the instructor was somewhat astounded to find that the estimate amounted to 25 tons per day.

Later, in a discussion, the pupils listed possible sources of error in this estimate and suggested ways of making the determination more valid. Considerable time was spent on this phase of the work since it seemed to be one of the most important parts of the entire project.

The following criticisms were mentioned:

Probability of considerable error in estimating the length, width and depth of the stream and the velocity of the water.

Uncertainty as to the correctness of the factor (0.8) used to obtain the mean velocity of the water from the surface velocity.

Possibility of error in measuring the volume of the sample of water and the weight of mineral material obtained from this sample.

Uncertainty as to whether the sample of water was truly representative for the day or even for the instant when it was taken.

Possibility that suspended material of colloidal dimensions had not been removed by filtration.

Probability of change in the weight of the dissolved minerals caused by chemical changes accompanying the boiling-off of the water.

The following fall the subject was introduced to the new class by asking the pupils what they supposed the amount of dissolved mineral material carried away by the creek each day to be. Their conjectures ranged from about 5 pounds to about 500 pounds. When they were told what the previous class had estimated, they were vociferously skeptical and expressed eagerness to check this figure.

At this point the instructor mentioned the criticisms of the experiment and suggestions for its improvement made by the previous class. Accordingly, it was decided to measure the length and width of the stretch of stream by tape, to determine

the mean depth by averaging measurements taken at frequent and regular intervals across the stream at several places, to obtain the average surface velocity by timing numerous sticks thrown into the stream at various distances from the banks, and to boil off a larger and more accurately measured sample of water.

The measurements were made as planned on November 17, 1943. The following data were obtained:

Length of the stretch of the creek	100 ft.
Average width	70 ft.
Average depth	9 in.
Average time for floating sticks to be carried the 100 feet	50 sec.
Volume of the sample of water	7.08 l. ($=\frac{1}{4}$ cu. ft.)
Weight of dissolved mineral material in the sample	0.98 g.[2]

Since the stream bottom was rough, a correction factor of 0.8 was used.

The rate of removal of dissolved minerals was found to be approximately 31 tons per day.

In order to determine roughly the limits of accuracy of this value, the pupils next estimated, to their best judgment, the probable limits of accuracy of each of the contributing measurements. For example, they decided that the 100-foot length was probably actually not less than $99\frac{1}{2}$ feet nor more than $100\frac{1}{2}$ feet, that the average width was actually between 68 and 72 feet, and that the actual average time taken for twigs to be carried 100 feet was not over 5 seconds more or less than 50 seconds. Then, by using those extremes which gave a maximum value on the one hand, and those which gave a minimum value on the other, the pupils arrived at a maximum of 45 tons per day and a minimum of 21 tons per day. However, since it is unlikely that the measurements were all too high or too low, the errors probably offset each other to a considerable extent, and the actual value probably lies well within the two limits.[3]

[2] This represents a mineral content of 138 parts per million; our measurement of October, 1942 indicated a content of 185 parts per million. According to data given in Clarke, pp. 74–76, the waters of rivers of this area contain from 70 to 170 parts per million of dissolved minerals. Of the rivers listed by him, the Genesee seems to be the most similar to Cobleskill Creek in regard to the nature of the bed and mantle rock of the drainage area. A sample of water of this river obtained at Rochester, N. Y. had a mineral content of 170 parts per million. These data suggest that our values are at least in the proper order of magnitude.

[3] It did not seem advisable to introduce the "square root of the sum of the squares" method of finding the precision measure of the result. Use of this method gives narrower probable limits of 37 and 25 tons per day.

If the estimated rate of 31 tons per day is correct, and if it is representative for the entire year, the amount of dissolved minerals carried by the creek past Cobleskill amounts to more than 11,000 tons per year.[4] Since this material is contributed by approximately 95 square miles, each square mile, on an average, loses nearly 120 tons per year. If the railroad that parallels the creek were to carry the annual load of dissolved minerals carried by the creek, a train of about 200 standard coal cars would be required.

Determining the Rate of Removal of Suspended Sediment

The present class decided to attempt to estimate the rate at which the creek is carrying off rock material in suspension. The measurements were made on March 21, 1945, during a period of dry weather. The creek was high at the time because of snow melting, but far from flood stage. The water was muddy, yet the stream bed could be discerned where the water was as much as a foot and a half deep.

The rate of flow of water was estimated as before and found to be nearly 37,000,000 cubic feet per day. A 23.30-liter sample of water was collected from near the surface of the stream. It was filtered through two thicknesses of filter paper, previously weighed to the nearest hundredth of a gram. The sediment left on the filter paper consisted of a fine brownish mud, with no particles larger than grains of silt. The filtrate water appeared perfectly clear, indicating that no appreciable amount of solid material had been carried through the paper.

The paper containing the sediment was then dried and weighed again. The weight of the sediment, found by subtract-

[4] To provide a rough check of our estimates of the annual flow of water in the creek, the instructor compared them with the annual run-off expectable on the basis of precipitation measurements. The average annual precipitation in this area is approximately 40 inches. On this basis, the volume of water that falls annually on the 95-square-mile basin of Cobleskill Creek above Cobleskill amounts to 8.8×10^9 cubic feet. Calculation of the ratio of run-off to precipitation for similar stream basins in this region, from data given in the 1941 Yearbook of the U. S. Department of Agriculture and Water Supply Paper 951 of the U. S. Geological Survey, shows that, as a rule, between 50 and 65 percent of the precipitation is carried off by streams, the rest being lost by evaporation and other processes. If the ratio for the Cobleskill Creek basin lies within these limits, as is likely, it follows that the expectable annual discharge of the creek at Cobleskill is between 4.4×10^9 and 5.7×10^9 cubic feet.

Our estimates of October, 1942 and of November, 1943 indicate that, if the flow on these dates represents average values, the annual discharge would be approximately 1.4×10^9 and 2.7×10^9 cubic feet, respectively. Both of these estimates are much too low, a fact to be expected because of the low level of the creek on these dates. Consequently, if the mineral content of the water of 138 parts per million, as determined in November, 1943, is representative for the year, and if the average annual discharge amounts to that expected on the basis of precipitation measurements, then the weight of minerals in solution carried past Cobleskill is more likely to be between 19,000 and 24,000 tons per year.

ing the original weight of the filter paper, was 0.69 gram. Since it seemed certain that some of the sediment consisted of minute organisms and organic debris, the filter paper containing the material was ignited to remove the organic matter, and the ash weighed. Then two identical sheets of filter paper were ignited, and the weight of the resulting ash subtracted from that of the filter paper and sediment. The weight of sediment after ignition was found to be 0.58 gram.[5]

Ignition of the sediment, besides removing the organic matter, undoubtedly also caused the partial decomposition of some minerals, especially carbonates, and oxidation of others, with a

FIG. 1. Cobleskill Creek, just southwest of Cobleskill, N. Y. One set of stream measurements was obtained at this site.

consequent change in weight. Although the amount of error introduced is unknown, it is probably not great. Possibly future classes will be able to determine the extent of this error, or to substitute a better method of removing the organic matter.

The rate of removal of rock material in suspension was then calculated and found to be nearly 29 tons per day. Probable limits of 47 and 18 tons per day were determined by the pupils, while use of the "square root of the sum of the squares" method gave limits of 37 and 21 tons per day.

Since the rate of discharge of the creek on the day the data were obtained was considerably higher than average,[6] and since

[5] This indicates a sediment content of the water of approximately 25 parts per million. According to data given by Dole and Stabler, p. 85, analyses of water from the Hudson, Delaware and Susquehanna Rivers show average sediment contents between 16 and 26 parts per million.

[6] Our estimate indicates, that, if continued at the rate which existed at the time the measurements

little inorganic sediment is carried during low water, this estimate is certainly too high for the year as a whole. However, during a total of about two months of the year the creek is generally about as high as when the measurements were taken. Furthermore, the water on this day was derived largely from melting snow (there had been practically no precipitation during the previous two weeks), and as pointed out by Gilbert, p. 231, run-off from this source carries less suspended sediment than that derived from rains.

With these facts in mind, it seems that our estimate is probably not more than five times as high as the actual average daily rate. If this is the case, more than 2000 tons of suspended sediment are being carried past Cobleskill each year, an average annual loss of about 22 tons for each square mile of the drainage area. This amount does not, of course, include sand grains and pebbles which are undoubtedly transported in large quantities by rolling and saltation along the creek bed.

A Final Word

The writer considers the foregoing project as having been successful in his classes. Some phases of the work have been difficult for the slower pupils, yet not impossibly so, while the brighter have found much to stimulate originality and critical thinking.

Possibly one reason for the appeal the project seems to have is that it constitutes, in a small way, original research. The pupils are not concerned with merely 'verifying' someone's law or in arriving at a value as close as possible to that in the book. They seem to take pride in realizing that *they* are the experts on this particular subject.

The project has been time-consuming. For even a small class to plan and carry out the field and laboratory work, do the calculations, criticize the method, and discuss the validity and significance of the findings has required five or more hours of class time, in addition to outside work. Moreover, the field work has necessitated the adjustment of schedules and other special arrangements.

The writer considers the value of the project to outweigh by far these difficulties. The time has certainly been well spent. It is true that the pupils could have been told a great many facts

were made, the discharge would amount to 13.5×10^9 cubic feet per year. This is two to three times as high as the rate expectable on the basis of the ratio between run-off and precipitation, as described in footnote 4.

in the same time, but this would hardly have resulted in as effective learning as that brought about by the solution of a real problem.

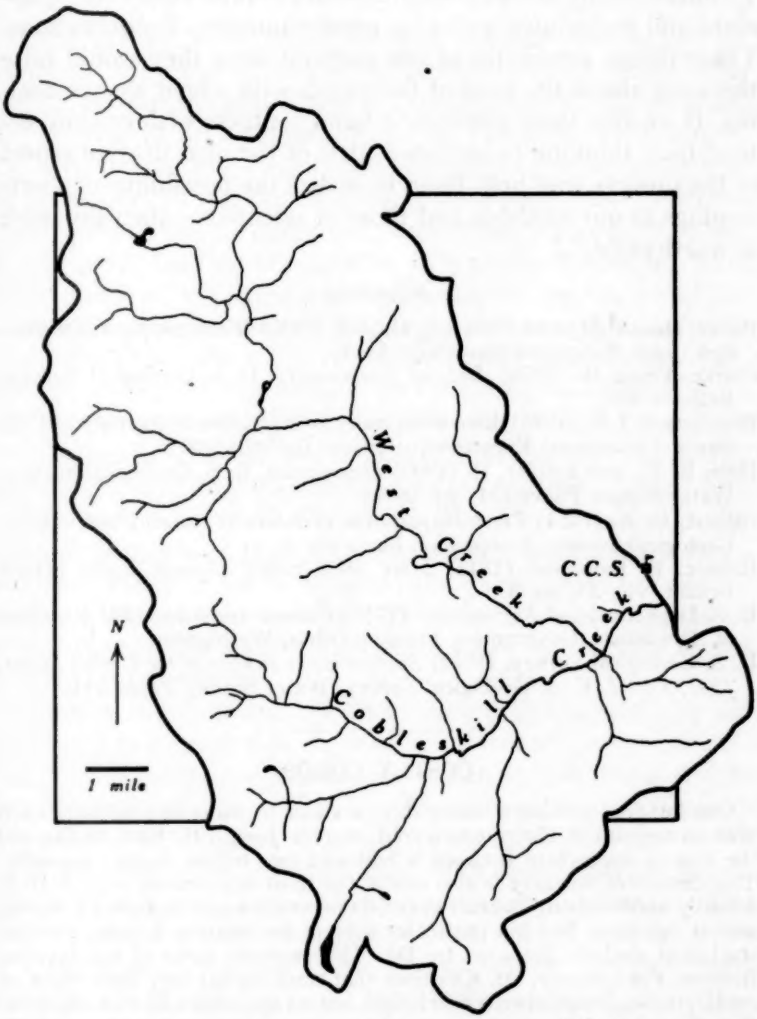


FIG. 2. Drainage basin of Cobleskill Creek above Cobleskill, from U.S.G.S. topographic maps. The square sheet represents an area of 100 square miles. The area of the drainage basin, approximately 95 square miles, was found by comparing the weights of the two pieces of paper cut to scale from the same heavy stock.

In regard to field work, any study of earth science that does not include at least some opportunity to observe real things

and real processes in their natural settings is not worthy of the name.

The validity of our estimates is, at the least, questionable. To obtain really accurate results would require elaborate equipment and techniques, and a far greater number of observations. These things would defeat our purpose since they would raise the work above the level of the pupils with whom we are dealing. If we give these pupils first-hand contacts with erosion, extend their thinking to include a little of the quantitative aspect of the process, and help them to realize the possibility of shortcomings in our methods and those of scientists—then the work is worthwhile.

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COSTLY COLDS

One hundred million working days are lost to American industry each year on account of the common cold, reports Joseph H. Kler, M.D., and the cost is somewhere between a half and two billion dollars annually. This expensive nuisance is also one of the most mysterious, since little is actually known about its exact cause, its prevention and its cure. Of course, almost everyone has his particular system for beating a cold, but the statistical analysis prepared by Dr. Kler explodes some of the favorite theories. For instance, Dr. Kler finds that smoking has very little effect on colds; staying home when a cold breaks has no apparent effect on the duration of a cold (although it is certainly easier on your working associates!)

Dr. Kler reports, however, fewer colds in air conditioned plants, and confirms that more colds start in draughty places. Posture is important, too, as people who walk about during their work contract fewer colds than those who sit all day. Women have more colds than men and they are severer, but the incidence in both men and women decreases with age. Strangely enough, more colds start on Monday than any other day in the week, particularly among men. (Perhaps this isn't so strange after all, since fatigue seems to be a factor in lowering resistance.)

GUAYULE—AN AMERICAN SOURCE OF RUBBER

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Until recent years, the United States has always had an abundant supply of rubber at its disposal. The major source of this supply was the milky juice of a tropical tree, *Hevea brasiliensis*, growing in large plantations on the South Pacific islands of Java, Sumatra, and Ceylon and the nearby Malay peninsula. So profitable did the rubber growing business become, with the greater world use of rubber and the abundant supply of cheap, native labor, that the plantations were greatly expanded. With the coming of the economic depression of the '30's and accompanying curtailment of rubber consumption, the industry was threatened with overproduction. It was little realized then how great would be the demand for rubber by the United States a few years hence to fight the greatest war of its history. It is well known how, late in 1941, most of this source of our rubber supply was cut off by the beginning of our war with Japan.

The Para rubber tree, *Hevea brasiliensis*, is a native of the western hemisphere. It grows in the tropical forests of the Amazon river valley in South America, the species name brasiliensis referring to its origin in Brazil. The tree grows equally well or even better in the East Indies where there is now such a vast acreage in plantations.

Another rubber-bearing plant of the western hemisphere has come into prominence recently as an alternative source of rubber. This is guayule, *Parthenium argentatum*, a native of northern Mexico and a portion of southern Texas, and particularly the desert of Chihuahua. Guayule (pronounced gwy-you'-lee) is a low growing, much branched shrub with slender silvery leaves, whence the species name *argentatum* (meaning silvered). The plant is adapted to warm regions of low rainfall, and does not withstand temperatures much below freezing for prolonged periods. The plants live to be 30 to 40 years old but under cultivation do not increase in rubber content much beyond the seventh or eighth year, because the new branches produced are compensated for by the loss of older branches. At this mature age of 7 or 8 years, the improved varieties of guayule contain 15–

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20% rubber, computed on the dry weight basis. Younger plants contain less rubber—progressively so with decreasing age. Year old plants contain but 1 to 2% rubber.

The guayule shrub resembles sagebrush in appearance and grows in a similar habitat as regards moisture—desert. Guayule contains a considerable quantity of resin, and when dry burns vigorously because of the rubber and resin content. The guayule plant belongs to the composite family of plants, sub-family Carduaceae, and as such is found to bear its flowers in compact heads. The flower heads are borne on numerous, long, slender flower stalks, giving a characteristic appearance to the plant. The flowers themselves are yellowish and rather inconspicuous. Seed production is abundant but the freshly-gathered, unthreshed seeds do not germinate in very high percentage unless treated with an oxidizing agent. Dilute solutions of calcium or sodium hypochlorite have been most commonly used for this purpose. Recent tests have shown that good germination may be obtained without this chemical treatment if the seeds are threshed (to remove certain adhering papery structures) and stored for six months to a year.

The rubber-bearing capacity of guayule has been known for a considerable number of years, but only limited quantities of guayule rubber have been marketed in recent years because the use of this type of rubber was restricted to certain purposes. However in the early years of the present century a considerable proportion of the rubber used in this country was from guayule. The areas where guayule grows naturally have been gradually depleted of this species over the years, and this process is still going on. Natural reproduction of guayule is slow and its growth, like that of other plants, is slow in the desert. It was for these reasons that attempts at cultivation were first started early in the present century. The success of these attempts is due to the large amount of experimentation expended on the plant through the intervening years. The fact that guayule is cultivated on the present wide scale might be considered remarkable, as it is not often that a plant is taken from its native home and domesticated in so short a time.

For the most part guayule is propagated by means of seeds, although new plants may be produced vegetatively by cuttings. Guayule seedlings are small and frail and cannot withstand serious competition from weeds. For this reason it has been cutomary to sow the seeds in nurseries and care for the seed-

lings there for about a year, after which time the plants are transplanted into fields. The nurseries are usually watered by means of overhead irrigation and are divided into sections by lath snowfences which serve as windbreaks. The nursery beds are frequently watered after sowing until the seedlings are well established. The beds are weeded by hand, or are sprayed with an oil which does a maximum amount of damage to the weeds and a minimum amount of damage to the guayule seedlings. At the end of the growing season the plants are ready for transplanting to the field. They are dug, packed in boxes, and shipped by truck or train, sometimes for long distances, to the field to be planted. Prior to digging, water is withheld for a considerable time and the plants are topped two or three inches from the ground. Both these practices greatly improve the plant's ability to renew growth and become established. Survival of the transplants is also favored by the occurrence of rains or by irrigation soon after planting in the field, as is true with other transplanted crops as well.

Recent work has indicated that it may be possible to sow guayule seed directly in the field where the crop is to be grown. Excess plants would be thinned out later as is done with other crops like sugar beets. If these methods prove successful, the costly step of growing the seedlings in the nursery for a year would be eliminated.

Tests have shown that guayule may be successfully grown in the desert and steppe climates of southwestern Texas, southern New Mexico, Arizona, and California, and the Mediterranean climate of central coastal California. North of these areas in Texas, New Mexico, and Arizona the winter temperatures are too low for survival of the plants, and north of these areas in California and east of these areas in Texas the greater rainfall permits root rot to attack the plants. Thus the region of the country suitable for growing guayule may be designated as the "arid Southwest." This region is more nearly like the native Mexican home of guayule than any other part of the United States.

Most of the work done with guayule before 1942 was under auspices of the Intercontinental Rubber Company with headquarters at Salinas, California. It was apparent after our entry into war with Japan that natural rubber could no longer be obtained from East Indian sources. Hence our country was faced with the necessity of conserving rubber and of developing other

sources of rubber to add to the considerable stockpile on hand which was expected to dwindle rapidly under wartime needs. Thus the manufacture of synthetic rubber from petroleum and from alcohol fermented from grain was vastly expanded. It was also desired to exploit the principal source of natural rubber in the United States—guayule. Accordingly, early in 1942 Congress authorized the Department of Agriculture to acquire all the California holdings of the Intercontinental Rubber Company and to embark on a large program of research on and production of guayule. These holdings consisted of nurseries, machinery, buildings, research data, a rubber extracting mill, a sizeable quantity of seed, and a small acreage of field plantings

FIG. 1. Field of year-old guayule in Salinas Valley, California.

of guayule. The Forest Service was given general charge of the program which was called the Emergency Rubber Project, with headquarters at Los Angeles, California. The specific work of the Forest Service was the production of guayule rubber, from sowing the seed to milling out rubber from harvested shrub.

Certain other bureaus of the Department of Agriculture were given the responsibility of carrying out an ambitious research program on quayule. One of the principal organizations established for this purpose was sponsored by the Bureau of Plant Industry and called the Guayule Research Project with headquarters in Salinas, California. Scientists from many parts of the country came to lend their training and abilities to the solution of numerous problems involved in the cultivation and mill-

ing of guayule. A great variety of experiments were set up in the field, nursery, greenhouse, and laboratory to throw light on insect pests and diseases of guayule, proper irrigation and fertilizer practice, and methods of extracting rubber from the shrub. Certain fundamental aspects of the physiology and genetics of the guayule plant are also being investigated in order to learn more about the chemical constituents and transformations occurring within the plant and to bring into being better varieties of guayule through breeding. Although much has been done through the years in improving guayule by selection, breeding offers greater promise in producing varieties which yield more rubber and are more resistant to cold and diseases. Results from these studies are published from time to time in the various scientific journals.

Rubber in the guayule plant does not occur in a milky fluid, exuding when the plant is cut. (When the guayule plant is cut or injured, clear resin usually exudes.) The rubber is found instead in individual cells, particularly of the bark of the stems and roots, both large and small. Specific tissues where rubber is found in largest amounts are the cortex, pith, and vascular rays. No rubber is contained in the conducting cells of the xylem and phloem or in the cork tissue of the bark, and very little rubber is present in the leaves. At the time of harvesting, the entire plants are dug up, allowed to dry in the field, baled, and stored where the drying process continues. The first step in milling consists of crushing and macerating the shrub. These processes rupture the plant cells and release the rubber contained within. During the maceration process water is mixed with the crushed shrub, and the resulting slurry is introduced into large vats filled with water. Here the water logged wood and cellulose tissue of the plant sink to the bottom and the rubber in the form of "worms" and the cork rise to the top and are skimmed off. The rubber "worms" and cork are separated from each other by subjecting them to high pressure and temperature, after which the cork sinks to the bottom of a second series of water-filled vats and the rubber rises to the top, again to be skimmed off. The rubber is then dried, pressed into 100-pound blocks, and boxed for shipment. At present there is but one operating factory for milling guayule rubber in the United States and it is located near Salinas, California. Another one, however, is being built near Bakersfield, California, and will be ready for operation in the near future.

All the guayule rubber produced by the Emergency Rubber Project's mill is allocated by governmental agencies to the various manufacturers of rubber products. A considerable part of the supply at present is used together with synthetic rubber in lining the non-explosive fuel tanks of airplanes. If such a tank is pierced by a bullet, the rubber lining seals the hole, thus preventing the escape of gasoline. Most of the rest of the present production of guayule rubber is blended with synthetic rubber in manufacturing tires for military and other essential war vehicles. No synthetic rubber thus far developed can be used alone in the body of tires for heavy duty or high speeds, because

FIG. 2. Close-up view of 10-year-old guayule plants, showing flower stalks of past season. (Ruler is 18 inches high.)

internal friction is so great that heating results with consequent deterioration of the tire fabrics. For this reason a certain proportion of natural rubber, either from the Para rubber tree or from guayule, must be blended with it to obtain long life and efficient service from the tire.

Guayule rubber contains about 18% resin, whereas Hevea rubber contains only about 4% resin. This high resin content of guayule rubber is of definite advantage when mixed with synthetic rubber, since the plasticity of the resulting product is increased and the material is more easily worked in the manufacturing processes. If it is desired to use guayule rubber for any purpose where the large amount of resin would be objectionable,

the resin content can be easily reduced to about 5% by extraction with chemical solvents. It would then be similar to Hevea rubber in regard to resin content. If this were done, the extracted resin would have use in the manufacture of plastics, as there is considerable demand for such raw materials.

Congress in 1942 authorized the planting of 75,000 acres of guayule, which in itself would have been an ambitious undertaking. However, the Baruch Committee report made public in the fall of 1942 urged still greater expansion of the program, and early in 1943 Congress authorized the planting of up to 500,000 acres. Money was appropriated to lease and plant 176,000 acres in the fiscal year beginning July 1, 1943 as the first step in this "all out" program. To provide plants for this vast acreage, the Emergency Rubber Project greatly expanded its nurseries at Salinas and established additional large nurseries in southern California and smaller ones in Arizona, New Mexico, and Texas. A good proportion of this new acreage of guayule field plantings was to have been made on high-priced, irrigated agricultural land in order to speed up the growth of the shrubs by irrigation and thus to produce a supply of rubber sooner. But before the new program got fully under way, the Rubber Director stated that the program for manufacturing synthetic rubber was making excellent progress, expressed reluctance to permit the use of so much food-producing land for guayule, and urged curtailment of the guayule planting schedule. As a consequence of his recommendation, no more land was leased and part of the leased land was returned to the owners. The total amount finally planted aggregated 32,000 acres, practically all of which is in California. About three-fourths of this acreage is on irrigated land and the remainder on dry land.

The Emergency Rubber Project is milling out guayule rubber as rapidly as possible. The factory at Salinas is running and will continue to run at full schedule. The factory being built at Bakersfield will start operation as soon as completed. In 1943 about 440 tons of guayule rubber was milled from old plantings of the Intercontinental Rubber Company in the Salinas Valley. In 1944 about 255 tons was milled from wild shrub harvested from southwestern Texas. The shrub now being milled is from the first plantings made by the Emergency Rubber Project, and is two to three years old. No data are yet available on the quantity of rubber yielded from plantings made since the war emergency arose. But this shrub will yield more rubber as it be-

comes older because of increases in size and rubber percentage. It is thought that the most economical time to harvest guayule shrub is after four to five years of growth in the field. Several years will be required to process all the shrub now planted on the 32,000 acres.

The future of guayule production is uncertain. Present plans do not call for the planting of additional acreage. Plantings now made will be cared for and milled out as soon as possible. After June, 1945 the research work on guayule will be drastically curtailed. Certain field experiments on various irrigation and fertilizer treatments and different spacings of plants will be continued. The numerous varieties and strains of guayule will be kept growing and a modest breeding program will be carried on. The present guayule expansion program under governmental supervision was purely a war effort, aimed at helping to relieve the critical rubber situation. Now that the situation does not appear so critical, it seems only proper that the program should be reduced. What the rubber situation will be after the war, when East Indian rubber is again available and improved synthetic rubber is manufactured on full scale, remains to be seen. But much valuable information has been gained on guayule from the research activities and practical experience on handling guayule. It is possible that guayule may become a stable agricultural crop under private control. As such it would serve as a domestic source of natural rubber, capable of being expanded should the need arise.

POSTWAR JOBS

Postwar employment prospects in 11 occupations are described in 11 different six-page Occupational Abstracts just revised and published by Occupational Index, Inc., New York University, New York 3, N. Y., at 25¢ each.

The occupations covered are:

Banking	Funeral Director
Boilermaker	Insurance Salesman
Bookkeeping	Journalism
City Fireman	Police Officer
Diesel Engines	Stenographic Work

Veterinarian

Each abstract summarizes available information on the nature of the work, abilities and training required, earnings, number and distribution of workers, advantages, disadvantages, and postwar prospects. Sources of further information and best references for additional reading are included.

SOLID REACTIONS

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Chemical reactions that occur between solids have not been studied so commonly as other types of reaction largely because the reaction velocity is in general, quite low and the difficulty involved in following the course of the reaction is very considerable. Numerous reactions occuring between solids, however, are known and some have been carefully studied. In 1885 Spring[1] pressed a mixture of powdered $BaSO_4$ and Na_2CO_3 together and reported that about 20% of the mixture was converted to $BaCO_3$ and Na_2SO_4. Furthermore Spring reported that when a mixture of powdered $BaCO_3$ and Na_2SO_4 was pressed together 80% of the mixture was converted to $BaSO_4$ and Na_2CO_3 from which it was concluded that a chemical equilibrium was reached as represented by the equation

$$80\ BaSO_4 + 80\ Na_2CO_3 \rightleftarrows 20\ BaCO_3 + 20\ Na_2SO_4$$

In discussing this reaction van't Hoff[2] said that this equilibrium would be inexplicable unless partial solid solubility[3] be assumed since otherwise the reaction must go to completion in one direction or the other. It is interesting to recall that $BaSO_4$ is converted to $BaCO_3$ to the extent of about 20% when a suspension of $BaSO_4$ in a solution of Na_2CO_3 is boiled in making a "Prepared Solution" for qualitative analysis. However a reaction between solids does not necessarily proceed the same as it does in solution, not even in the same direction. Indeed new and unknown compounds may sometimes be prepared by means of solid reactions. In this way Tammann and Rosenthal[4] prepared a whole series of previously unknown uranates.

Roberts-Austen,[5] at about the turn of the century, observed that solid gold will migrate into solid lead at temperatures under 100° against the force of gravity but estimated that "the amount of gold (solid) which would diffuse in solid lead at or-

[1] Soc. Chim. de France, Bull. nouvelle series, *44*, 166–169 (1885).

[2] Zeitschrift für Physikalishe chemie, *5*, 325 (1890).

[3] In the most common type of solid solution the atom, ion or other crystal unit of one crystalline solid penetrates the other crystalline solid and occupies a corresponding position in a perfectly random fashion. Many of the properties of the resulting solid solution are intermediate between those of the pure crystals. It is well known that when a molten mixture of gold and copper of any composition freezes the resulting crystals (after thorough annealing) have the same composition as the original mixture and the gold and copper atoms are found to have penetrated into and among each other in a random fashion.

[4] Z. anorg. all gem. chemie, *156*, 20 (1926).

[5] Philos. Trans. Roy. Soc., Ser. A, *87*, 383 (1896); Proc. Roy. Soc., *67*, 101 (1900).

dinary temperature in 1000 years is almost the same as that which would diffuse into molten lead in one day." It is obvious that the slow reaction velocity of a solid reaction must be intimately related to the low rate at which one solid diffuses into another.

In 1912 Hedvall[6] showed that many types of ceramic products could be prepared at temperatures far under the fusion temperature and without the use of a flux. From that day to the present the ceramic industry has been greatly interested in reactions of this sort. Numerous studies of oxides reacting in the solid state have been made as an example of which may be sighted the work of Ward and Struthers.[7] Other important examples must be omitted and space does not permit more than the mention of what is undoubtedly the most important solid reaction of all, the reaction of carbon with iron.

Some interesting results have been obtained for ionic exchange reactions that occur between crystals under the fusion temperature. Ionic double decompositions that produce a color change have been reported by van Klooster[8] among which were

$$PbCl_2+2KI\rightarrow PbI_2+2\ KCl$$
$$PbS+CdSO_4\rightarrow CdS+PbSO_4$$
$$K_2S+CdSO_4\rightarrow CdS+K_2SO_4$$
$$HgCl_2+2KI\rightarrow HgI_2+2KCl$$

and it was further reported that cadmium lithophone, usually prepared in the wet way, can be prepared in the dry way according to the reaction

$$BaS+CdSO_4\rightarrow CdS+BaSO_4$$

Tubandt and Reinhold[9] have studied the reciprocal reactions

$$Ag_2S+2CuI\rightleftarrows Cu_2S+2AgI$$
$$Ag_2S+Cu_2Se\rightleftarrows Cu_2S+Ag_2Se$$

and have reported that an equilibrium is reached in either case at temperatures under the fusion point. The equilibrium mixture for the first reaction was made up of one solid solution of the pair Ag_2S–Cu_2S and another of the pair AgI–CuI while in the second case the equilibrium mixture was made up of the solid solution Ag_2S–Cu_2S and Cu_2Se–Ag_2Se. These authors assumed that only the cations migrated and their analytical results were based on this assumption. A small pellet of Ag_2S and another of CuI were placed in contact and held at the reaction temperature

[6] Ber. Chem. Ges., *45*, 2095 (1912).
[7] J. Am. Chem. Soc., *59*, 1849 (1937).
[8] J. Chem. Ed., *17*, 361 (1940).
[9] Z. physik. Chem., 140A, 291 (1929).

until equilibrium was reached after which they were broken apart and weighed. There will be a net gain in the weight of the iodide pellet due to the exchange of copper ions for silver ions and there will be a net loss weight of the sulfide pellet due to the exchange of silver ions for copper ions. The composition of the equilibrium mixture could be calculated from the weight changes of the pellets and the equilibrium mixture was found to be the same when approached from either side. When a change in the starting mixture was made the equilibrium shifted in accordance with the demands of the Law of Mass Action and an attempt was made to use equilibrium constants, obtained at different reaction temperatures, for calculating the heat change due to the reaction.[10]

These results reported by Tubandt and Reinhold are interesting but the method of analysis could not be widely used because the rate of diffusion would not be sufficiently rapid in many cases. Also the validity of the assumption that the two pellets will always break at the original boundary appears to be open to considerable doubt. While cooling curves, microphotographs and other methods have been used for analyzing solid mixtures the method of x-ray crystal analysis first reported by Friedrich, Knipping and von Laue[11] in 1912 and rapidly developed by W. H. Bragg and W. L. Bragg[12] and a host of others, is peculiarly adaptable to the analysis of a mixture of crystals such as is described in the preceding paragraph. In 1916 Debye and Scherrer[13] and in 1917 Hull,[14] showed that if a beam of monochromatic x-rays of a suitable wave length is passed through a defining slit and ther. through a mixture of very small crystals (crystals that will pass through a 200 mesh sieve and which are arranged in a random fashion) interference beams emerge from the mass of crystals at characteristic angles[15] which can be photographed

[10] If the heat change, ΔH, can be assumed to be constant over the temperature interval then

$$\Delta H = \log \frac{K_2}{K_1}\left(\frac{T_2 \times T_1}{T_2 - T_1}\right) 2.3 \times R$$

where K_2 is the equilibrium constant at T_2 and K_1 is the equilibrium constant at T_1. For the $Ag_2S - CuI$ reaction Tubandt and Reinhold report a value of 12.7 kg. cal. calculated from the equilibrium constants at 200°C. and 300°C. and an average value of 12.6 kg. cal. as estimated from the heats of formation.

[11] Ber. bayer. Akad. Wiss. (Math-phys. Kl), 303 (1912).

[12] X-rays and Crystal Structure, London, 1915.

[13] Physikal Z. *17*, 277 (1916).

[14] Phys. Rev., *10*, 661 (1917).

[15] The Braggs showed that the interference phenomenon could largely be treated as the geometric equivalent of a "reflection" from the surface of the crystals combined with other "reflections" produced by other planes of atoms (ions or other crystal units) lying beneath the surface and parallel to it. The

or otherwise detected. If the interference beams are photographed, images of the defining slit will be found on the photographic film and this series of lines, similar in appearance to light spectra, is called the interference pattern. Each type of crystal produces a characteristic interference pattern and when a mixture of crystals is photographed each type of crystal in the mixture produces its own pattern entirely independently of the others. This very subtle and penetrating method for analyzing crystals has been freely used by the author and his co-workers[16] in the work on solid reactions that has been carried on for more than a decade at St. Louis University.

Reciprocal Reactions of the Alkali Halides

When an equimolar mixture of KCl and NaBr was heated for 36 hours at 500°C. the x-ray analysis showed clearly an interference pattern whose absolute dimensions[17] were too large for either KCl or NaBr. When all of the interference lines were carefully examined they were found to correspond precisely (within the limit of error) to a mixture of two patterns, one for pure NaCl and the other for pure KBr. It is obvious then that KCl and NaBr reacted chemically to form NaCl and KBr according to the reciprocal reaction

$$KCl + NaBr \rightarrow NaCl + KBr$$

When this same mixture of KCl and NaBr was heated at 400°C. for 36 hours all four interference patterns were observed which indicated that while some KCl and NaBr reacted to form NaCl and KBr the reaction was not complete. When an equimolar mixture of NaCl and KBr (the opposite pair) was heated at 400°C. for 36 hours the interference patterns were only those of the pure reactants. There was no reversal of the reaction indicated above and it might be presumed that if the KCl–NaBr pair were heated at 400°C. for a sufficient length of time that the reaction would be complete and that only NaCl and KBr would remain as was found to be the case after 36 hours at 500°C. When an equimolar mixture of the KCl–NaBr pair was

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fundamental equation is

$$n\lambda = 2d \sin \theta$$

where λ is the wave length of the x-rays, d the perpendicular distance between atom planes, θ the angle of incidence and n is a whole number (the order number of the interference line).

[16] Lyman J. Wood, *J. Am. Chem. Soc.*, *52*, 3833 (1930); *J. Chem. Ed.*, *8*, 952 (1931); E. B. Thomas with Lyman J. Wood, *J. Am. Chem. Soc.*, *56*, 92 (1934); *57*, 822 (1935); *58*, 1341 (1936); H. L. Link with Lyman J. Wood, *J. Am. Chem. Soc.*, *60*, 2320 (1938); *62*, 766 (1940); J. Wm. Vogt with Lyman J. Wood, *J. Am. Chem. Soc.*, *66*, 1259 (1944); F. J. Zvanut, L. J. Wood, C. M. Dodd and W. T. Schrenk, Pyrochemical changes in Missouri Halloysite, *University of Missouri School of Mines and Metallurgy Bull.*, 12, No. 3, March 1937; F. J. Zvanut and L. J. Wood, x-ray investigation of the pyrochemical changes in Missouri Halloysite, *Jour. Am. Ceramic Soc.*, *20*, No. 8 (1937).

[17] Values of d in the Bragg equation.[15]

ground vigorously in a mortar at room temperature for 15 minutes the four interference patterns of KCl, NaBr, NaCl and KBr were observed and the reaction appeared to be approximately 50 per cent complete.

The change in free energy for this reaction as calculated from specific heat data[18] was found to be -1.93 kg. cal./g. mol. at 25°C. from which the reaction would be expected to show a tendency to proceed from left to right at room temperature and although data are not available for making this calculation at 400°C. it would not be surprising if the free energy were still negative by about the same amount. Also the average cube edge[19] of the NaCl–KBr pair is less than that of the pair KCl–NaBr from which it appeared that a study of the effect of pressure on this reaction might prove interesting.[20] This idea was tested by compressing an intimate and carefully dried mixture of KCl and NaBr in a hydraulic press at 3500 atmosphere per square inch for 10 minutes. The x-ray analysis showed the presence of four interference patterns, corresponding to KCl, NaBr, NaCl and KBr and, as nearly as could be judged from the relative intensities of the lines, about 50 per cent of the solid KCl and NaBr reacted with each other in 10 minutes at room temperature for form solid NaCl and KBr!

The reciprocal reaction just described is one of 60 such reciprocal reactions that can be set up when the common halides of lithium, sodium, potassium, rubidium and cesium are considered. All 60 of these reciprocal reactions have been studied in the author's laboratory, some only in a preliminary way and some in considerable detail and many of the common ion salt pairs associated with these reactions have also been studied. In order to facilitate a discussion of the results obtained the chart shown in figure 1 will be found to be quite useful. It is proposed that this chart be called the Reciprocal Chemograph.

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[18] The free energy change is known to be a measure of the reaction tendency and was calculated by means of the relation

$$\Delta F = \Delta H - \Delta S$$

where ΔF is the change of free energy, ΔH is the heat of reaction and ΔS is the entropy change. The entropy was calculated by means of the relation

$$S = \frac{L}{T} + \int_o^t Cp \frac{dT}{T}$$

where S is the entropy, L is the molecular heat of fusion, T is the absolute temperature and Cp is the specific heat.

[19] It is known that KCl, NaBr, NaCl and KBr all crystalize in the cubic system. The cube edge is the distance along any of the cubic axes from one metal ion to the next.

[20] Spring subjected a mixture of 1 part $BaCO_3$ and 3 parts Na_2SO_4 to a pressure of 6000 atmospheres and reported a 59.2% conversion to the reciprocal pair while G. Tammann and B. Garre [Z. für anorg. u. allg. Chem. *149*, 52 (1925)] pressed a mixture of Na_2CO_3 and $BaSO_4$ at 1000 atmospheres and reported no conversion.

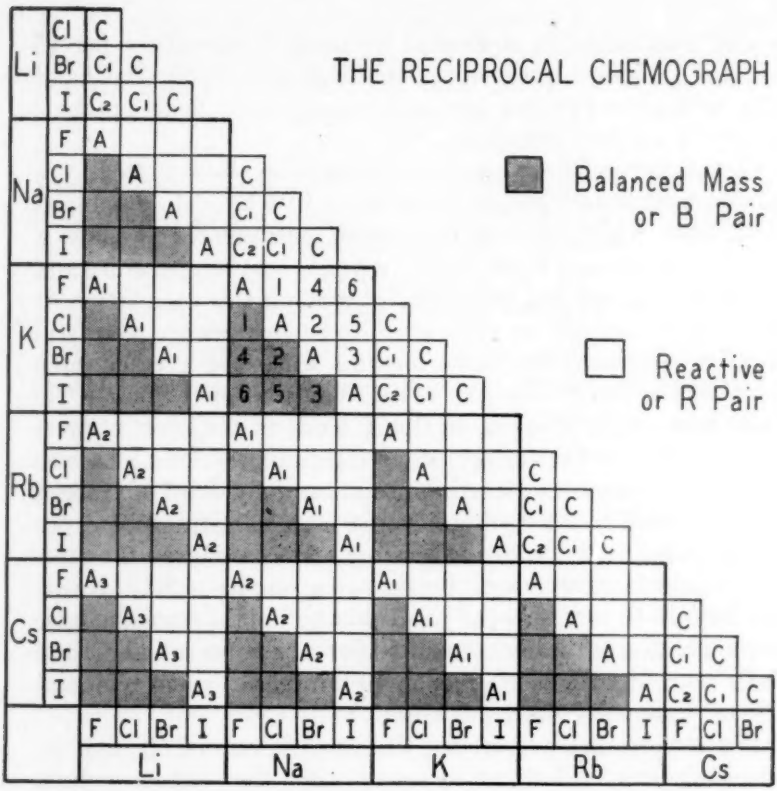

FIG. 1. Each of the shaded squares represents the salt pair of a reciprocal reaction that has the heavier of the cations united with the heavier of the anions and the ligher of the cations united with the lighter of the anions. This pair of salts is referred to in the discussion as the Pair of Balanced Mass or more briefly, the *B* pair. An open square represents a pair of unbalanced mass which is referred to in the text as the reactive pair or simply the *R* pair, since most of these salt pairs react chemically to form the *B* pair at temperatures far under the fusion point. The main body of the chemograph will be seen to be made up of units of 16 squares of which the six in the lower left hand corner represent *B* pairs and the six in the upper right corner represent corresponding *R* pairs (see numbered unit). The salt pairs having common cations are represented by the letter *C* if the halogens are next to each other in the periodic table, by C_1 if they are once removed (e.g. Cl–I) and by C_2 if they are twice removed. The common anion pairs are represented in an analogous manner by *A*, A_1, A_2, and A_3. The common ion pairs corresponding to each reciprocal reaction are to be found in convenient unique positions in the horizontal and vertical rows that intersect in the *B* pair.

A study of the reciprocal chemograph shows that the 20 salts are arranged to make up 190 salt pairs. There are 30 common cation pairs, 40 common anion pairs, 60 pairs of balanced mass

(*B* pairs) and 60 reactive pairs (*R* pairs). One *B* pair and one *R* pair are included in each reciprocal reaction, hence there are 60 reciprocal reactions to be studied. Each cation occurs in 24 reactions and each anion occurs in 30 reactions. For each reaction there are two common cation pairs and two common anion pairs. Each common cation pair is associated with four different reactions and each common anion pair is associated with 3 different reactions.

Before beginning a study of these salt pairs in the crystalline state an equimolar mixture of each *R* pair was fused and quickly quenched from the molten condition[21] and the resulting crystalline mixture examined by the method of x-ray crystal analysis. The results indicated that 57 of the 60 *R* pairs reacted completely to form the *B* pair of salts and it was found that in each of these 57 cases, without exception, the average cube edge[19] of the *B* pair was less than that of the *R* pair and the sum of the heats of formation (at room temperature) was greater. These correlations hold some very considerable interest although they cannot be said to be especially surprising.

The average cube edge values and sums of heats of formation for the remaining three reactions are summarized in Table I.

TABLE I. *R* PAIRS SHOWING INCOMPLETE REACTION IN THE FUSED STATE

	R Pair	*B* Pair
Av. cube edge in A°	RbBr+CsCl ⇄ 5.489	RbCl+CsBr 5.430
Sum of hts. of formation in kg. cal./g. mol.	202.5	202.4
Av. cube edge in A°	RbBr+KI ⇄ 6.960	RbI+KBr 6.947
Sum of hts. of formation in kg. cal./g. mol.	174.8	174.8
Av. cube edge in A°	KBr+RbCl ⇄ 6.570	KCl+RbBr 6.574
Sum of hts. of formation in kg. cal./g. mol.	199.0	200.3

[21] Because of the low veocity of these reactions at room temperature it was assumed that the proportion of salts in the solid mixture at room temperature would be the same, or nearly the same, as at the fusion temperature.

The x-ray analysis showed that the *R* pair of the first was converted to the *B* pair to the extent of 50 per cent while the conversion for the second reaction was somewhat less than 60 per cent. The last reaction presented a very interesting situation. Only one interference pattern was obtained and this one pattern was the one that would be expected from a solid solution[3] of the four kinds of ions. When either the *R* pair or the *B* pair used as the starting mixture was no longer equimolar there still was only one interference pattern but the absolute dimensions of the pattern changed quantitatively as calculated for the new composition. The common cation pairs KCl–KBr and RbCl–RbBr associated with this reaction as well as the common anion pairs KCl–RbCl and KBr–RbBr are each known to form solid solutions stable at room temperature. As is to be seen from Table I the average cube edge values for the *R* and *B* pairs are very nearly the same as are the sums of the heats of formation. It does not appear to be possible to say how much *B* pair and how much *R* pair was present in such a homogeneous solid solution of the four kinds of ions.

Chemical Reaction of the Alkali Halides Below the Fusion Temperature

A study of these same 60 reactions below the fusion temperature presented greater difficulty and was more laborious. In most cases the reaction mixtures had to be heated for long periods of time (in some cases, weeks) at several hundred degrees centigrade. The salt mixtures resulting from these reactions under the fusion temperature often produced poor interference patterns, the measuring of which was extremely exacting and time consuming. Although several hundred heat treatments have been made and the resulting mixtures analyzed by the method of x-ray crystal analysis, still scarcely more than a beginning has been made in the careful investigation of all of the salt pairs and reciprocal reactions indicated in the Reciprocal Chemograph.

All of the results obtained by heating equimolar mixtures of the 60 *R* pairs and the 60 *B* pairs at 100° to 200° under the fusion temperature for 36 hours are summarized in Table II. At the end of this time all of the *R* pairs showed some conversion to the *B* pair except the pairs NaBr–LiI, KBr–LiI and RbBr–KI. Nineteen of these reactions appeared to go to completion in the direction of the *B* pair and 16 of these 19 *B* pairs contained

the fluoride ion. After the 36 hour heating period 15 *B* pairs showed some reversal towards the *R* pair but no reaction was complete. It is interesting to note that not one of the 30 *B* pairs that contain the fluoride ion showed any reversal. Examination of Table II reveals that nearly all *R* pairs tend to form their respective *B* pairs, the pairs of balanced mass. It is also to be seen that the formation of a solid solution, stable at room temperature, has been found to occur more frequently among the common cation pairs than among the common anion pairs.

An indication of no reaction in Table II does not necessarily mean that the ion pair cannot react. It may mean that the reaction was so slow at the temperature at which the pair was heated that no appreciable amount of reaction was observed after 36 hours of heating. Also an indication of incomplete reaction in Table II does not mean that reaction will not be complete after a longer heating period. The velocity at which crystals react with each other is thus seen to be an important consideration.

Velocity of Solid Reactions

A temperature range in which a crystal attains sufficient energy for its crystal units to become mobile has been described. This temperature range has been called the "Loosening Temperature" by Hahn[22] and the "Agglomeration Temperature" by G. Tammann[23] and is about .5 to .6 of the absolute melting temperature. In the author's laboratory little reaction in the solid state was found until the temperature was about 250° above this loosening temperature (100° to 200° under the fusion temperature) after which the reaction velocity sometimes increased notably during the next 50 to 100 degrees. In figure 2 the difference between the temperature of the melting range, *Tm*, and the reaction temperature, *Tr*, is plotted against the extent of the reaction for a 36 hour heating period. No smooth curve can be drawn through the points but there is a very obvious increase in reaction velocity as the reaction temperature approaches the melting temperature. One reaction, which was found to be complete after 72 hours at approximately 100° under the fusion point was found to be incomplete after 7 days at 180° under the fusion point. At this same temperature the reaction was complete after 14 days but there was no detectable

[22] *Z. physik, Chemie, 326,* 353 (1934).
[23] *Z. anorg. allgem. Chemie, 176,* 45 (1938).

TABLE II. SHOWING THE RESULTS OBTAINED FOR THE 190 SALT PAIRS[a]

	Cl	C																		
Li	Br	C1	Ct																	
	I	C2	C1	Cn																
	F	A	Rp	Rt	Rt															
	Cl	Bn	An	Rp	Rp	C														
Na	Br	Bn	Bp	An	Rn	C1	Cp													
	I	Bn	Bp	Bp	Ap	C2	C1	Cp												
	F	A1	Rt	Rp	Rp	A	Rt	Rp	Rp											
	Cl	Bn	A1	Rp	Rp	Bn	An	Rp	Rp	C										
K	Br	Bn	Bn	A1	Rn	Bn	Bn	A	Rt	C1	Ct									
	I	Bn	Bp	Bn	A1	Bn	Bn	Bn	An	C2	Cn	Cp								
	F	A2	Rt	Rt	Rt	A1	Rt	Rt	Rt	At	Rp	Rp	Rt							
	Cl	Bn	A2	Rp	Rp	Bn	A1	Rp	Rp	Bn	At	Rp	Rp	C						
Rb	Br	Bn	Bn	A2	Rp	Bn	Bn	A1	Rp	Bn	Bn	At	Rn	C1	Ct					
	I	Bn	Bp	Bp	A2	Bn	Bp	Bp	A1	Bn	Bn	Bp	At	C2	C1	Ct				
	F	A3	Rt	Rt	Rt	A2	Rp	Rt	Rt	A1	Rp	Rp	Rp	A	Rp	Rp	Rp			
	Cl	Bn	A3	Rp	Rp	Bn	A2	Rp	Rt	Bn	A1	Rp	Rt	Bn	An	Rp	Rp	C		
Cs	Br	Bn	Bn	A3	Rp	Bn	Bp	A2	Rp	Bn	Bp	A1	Rp	Bn	Bp	A	Rp	C1	Ct	
	I	Bn	Bp	Bp	A3	Bn	Bn	Bp	A2	Bn	Bn	Bn	A1	Bn	Bn	Bn	A	C2	C1	Ct
		F	Cl	Br	I	F	Cl	Br	I	F	Cl	Br	I	F	Cl	Br	I	F	Cl	Br
		Li				Na				K				Rb				Cs		

[a] The letter n indicates no reaction; p partial reaction; t to complete or total reaction. Solid solutions (stable at room temperature) of the common ion pairs are described by means of the same letters. Common ion pairs not investigated are marked as in the Reciprocal Chemograph.

change after one year at room temperature (about 550° under the fusion point).

It has been observed that the speed of these reactions is much faster in the beginning. When the *R* pair, NaI–KBr was heated at 50° under the melting temperature for 0.5 hour there was about a 20% conversion to the *B* pair. After 2 hours the conversion was about 35%, after 15 hours about 80% and after 30 hours about 90%. In 2 or 3 cases it appeared that the reaction was 80% to 90% complete in about ½ the time required for the

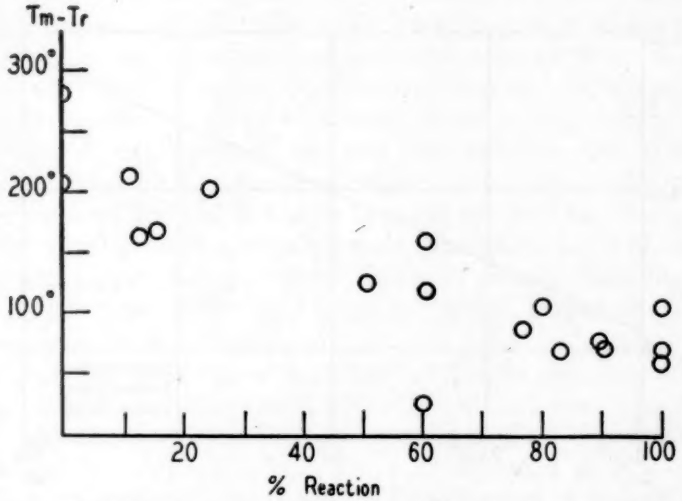

FIG. 2. Showing the relation between melting range, *Tm*, reaction temperature, *Tr* and the per cent of reaction for a 36 hour heating period.

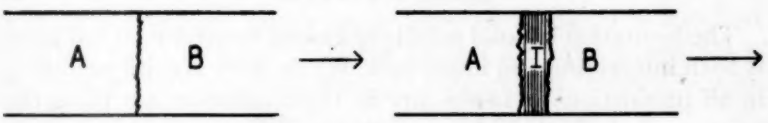

FIG. 3. Showing a diagram of the Reaction Layer.

completed reaction. For a possible mechanism for certain types of solid reactions W. Jander and E. Hoffmann[24] have suggested a "Reaction Layer." If the reaction layer (figure 3) becomes thicker as the reaction proceeds the velocity of the reaction would be faster at first and would decrease with time which is in

[24] *Z. Anog.* and *Allgem Chemie, 218*, 211 (1934).

good agreement with the observations described above. Since all of the powders used were passed through a 250 mesh sieve the reaction layer would be quite thin. A cube passing a 250 mesh screen could be as large as .007 cm. and the reaction would begin on all sides, hence the thickness of a reaction layer could not be more than a fraction of .0035 cm. (a crystal of NaCl measuring .007 cm. between the cube faces would contain almost 250000 interleaving ion planes parallel to any pair of cube faces). The thickness of the reaction layer would undoubtedly depend upon the temperature as well as upon the pressure.

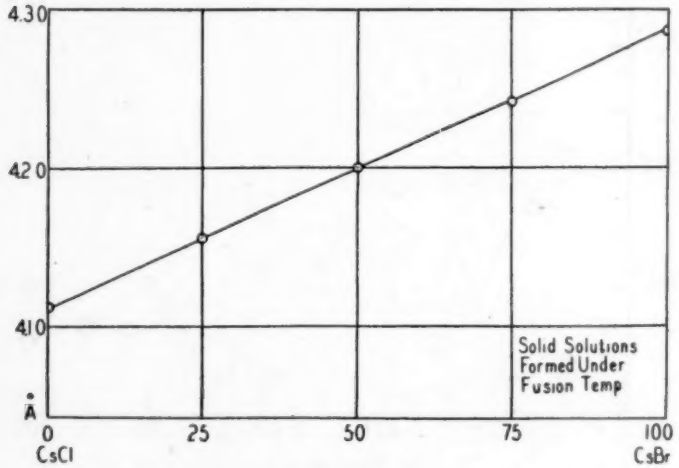

FIG. 4. Showing the relation between the cube edge of the CsCl–CsBr solid solution and percentage composition.

SOLID SOLUTIONS

The formation of solid solutions among the common ion pairs is both interesting and important. When there is solid solubility in all proportions between any of these common ion pairs the x-ray analysis shows only one interference pattern, the absolute dimensions of which are, for the most part, intermediate between the values for those of the pure salts and the quantitative relationship is very close to that of a simple proportion, e.g., if the mixture is equimolar the cube edge is half way between the cube edge values for the pure salts. This relationship due to Vegard[25] has been confirmed by Havighurst, Mack and Blake[26]

[25] *Z. Physik*, *5*, 17 (1921).
[26] *J. Am. Chem. Soc.*, *47*, 29 (1925).

working especially with the mixture KCl–KBr. In the author's laboratory this relationship has been confirmed for the KCl–KBr mixture, the CsCl–CsBr (figure 4) mixture and others. Recent very careful work with the CsCl–CsBr mixture has shown slight deviations from the curve shown in Fig. 4 but there can be no doubt that the rule is a very close approximation for these mixtures.

The mechanism by means of which these solid solutions form is a very interesting problem. An examination of the KCl–KBr case reveals that the crystal of KCl is cubic and that the crystal of KBr is also cubic but that while the arrangement of the ions is the same the corresponding distances between them is not the same. The arrangement of ions that best explains the interference patterns of KCl and KBr is shown in Fig. 5 in which the solid circles represent bromide ions and the open circles chloride ions. In Fig. 5a the arrangement of ions in the cube face is shown and the distances between the ions are drawn to scale. Directly below and parallel are successive planes of identical ion composition, the (100)[27] family of planes. These planes are 3.14 A° (3.14×10^{-8} cm.) apart in the KCl crystal and 3.28 A° apart in the KBr crystal.

Figure 5b shows the arrangement of ions in the planes perpendicular to the cube face and parallel to the face diagonal, the (110) family of planes. These successive layers of planes are identical in composition and are 2.22 A° apart in KCl and 2.32 A° in KBr. Fig. 5c shows the arrangement of ions in the planes that are perpendicular to the body diagonal, the (111) family of planes. The ions in these planes form equilateral triangles and alternate planes are made up of all potassium ions and all halide ions. These planes are 3.64 A° apart in KCl and 3.80 A° apart in KBr. In either crystal each potassium ion is surrounded by six equally related halide ions and each halide ion is surrounded by six equally related potassium ion.[28]

An equimolar solid solution of KCl and KBr, which forms readily when a mixture of the small crystals is heated at 480°C. for 36 hours, produces one x-ray interference pattern whose absolute dimensions are midway between those of pure KCl and

[27] Planes and families of planes are conveniently labeled by a system of index numbers originated by Miller. The numbers depend upon the intercepts of the plane with the respective crystallographic axes.

[28] Since it is not possible to say that any one potassium ion belongs to any one halide ion it is misleading to speak of a molecule of potassium chloride and the formula KCl in reality represents the smallest amount of potassium chloride that can have the known composition of this compound. The name stoichiometric molecule may be used to indicate the amount of potassium chloride represented by the formula KCl.

pure KBr. From this single interference pattern it can be inferred that each halide ion is still surrounded by six equally related potassium ions and each potassium is surrounded by six equally related halide ions, 3 of which are chloride and 3 of which are bromide. Several interesting questions may be raised. Does a chloride ion leave the KCl crystal and enter the KBr crystal

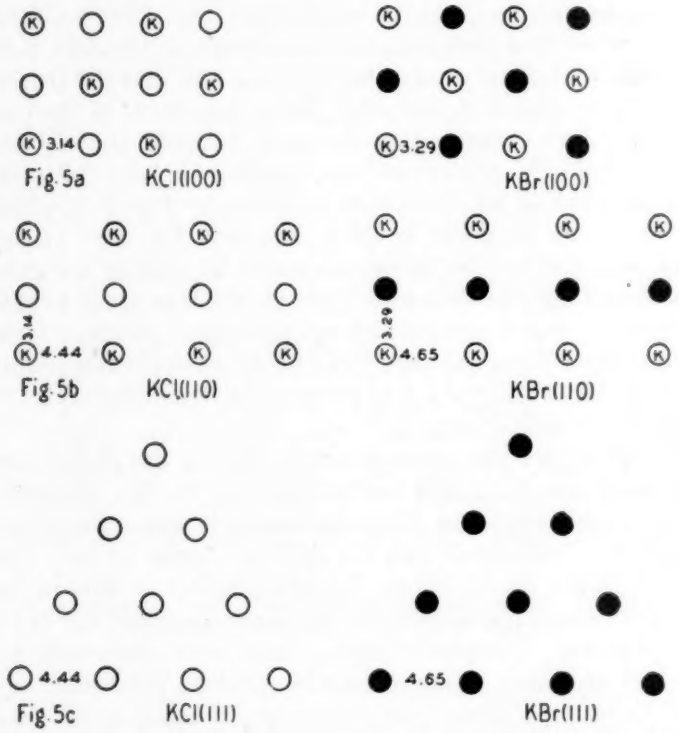

FIG. 5. Showing the ion arrangement in KCl and KBr. The black circles represent bromide ions and the open circles chloride ions.

at the same time that a bromide ion leaves the KBr and enters the KCl? Do potassium and bromide ions leave the KBr crystal in pairs and enter or add on to the KCl crystal? Do potassium and chloride ions leave the KCl and enter or add on to the KBr?

Matson and Beach[29] heated a mixture of KCl and KBr at 500°C. and at frequent intervals of a few hours, removed samples and made x-ray interference patterns. These authors report that at first there were two patterns, one having the absolute

[29] *J. Am. Chem. Soc.*, *63*, 3470 (1941).

dimensions of pure KCl and the other having the absolute dimensions of a pattern smaller than that of pure KBr and that with time the intensity of the pure KCl pattern decreased while the intensity of the other pattern increased as its absolute dimensions became smaller. These results would seem to indicate that the potassium and chloride ions left the KCl crystal and entered the KBr. Somewhat similar results were obtained in the author's laboratory on one occasion when two solid solutions of CsCl and CsBr formed as the *R* pair, KBr–CsCl was being slowly converted to the *B* pair at a low temperature. After further heating only one CsCl–CsBr solid solution pattern remained.

The KCl–KBr solid solution appears to be quite stable. Zemczuzmy and Rambach,[30] on the basis of heats of solution measurements, have reported that an equimolar KCl–KBr solid solution showed a partial breakdown into KCl and KBr after one and one-half months at room temperature. This finding has not been confirmed in the author's laboratory where such an equimolar solid solution, when analyzed with the x-ray beam after aging for more than 4 years at room temperature, showed no evidence of a breakdown. Although this solution has not been observed to form from KCl and KBr at 400°C. still it showed no evidence of decomposition after being heated for 288 hours (12 days) at 360°C. when examined by either the x-ray method or the index of refraction method.[31] It was noted with considerable interest, however, that a solid solution of KCl and KBr did form as the *R* pair, CsCl–KBr was converted to its *B* pair at 400°C. and furthermore when pure KCl was heated with a previously prepared equimolar KCl–KBr solid solution at 360°C. for 28 days, the index of refraction method showed that the solid solution had been enriched with KCl.

Chemical Equilibrium in Solid Reactions

When an equimolar mixture of the *R* pair, KBr–CsCl, was heated at 477°C. the reaction proceeded partially but incompletely to the *B* pair, KCl–CsBr and the residual KBr formed a solid solution with the KCl produced by the reaction while the residual CsCl formed a solid solution with the CsBr. By measuring the cube edges of the solid solutions by means of the x-rays

[30] *Z. Anorg.* and *Allg. Chem.*, *65*, 427 (1910).

[31] The index of refraction appears to change quantitatively with the composition of the solid solution and while it is quite sensitive its usefulness is limited because it is a surface phenomenon.

it was possible to follow the course of the reaction and it was found that there was a gradual conversion to the *B* pair until the change was 88.8 per cent complete after which there was no further change. When the *B* pair was heated at 477°C. there was a gradual conversion to the *R* pair until the change was 11.2 per cent complete after which there was no further change. It is clear that the reciprocal reaction reached an equilibrium expressed by the equation

$$11.2KBr+11.2CsCl\rightleftarrows 88.8KCl+88.8CsBr$$

When either KBr or CsCl was added to the left hand side the equilibrium shifted to the right and when CsBr or KCl was added to the right hand side the equilibrium shifted to the left. The shifts in equilibrium were in quantitative agreement with the requirements of the Law of Mass Action. When the *R* or *B* pair were heated at 400°C. an equilibrium, reached after 14

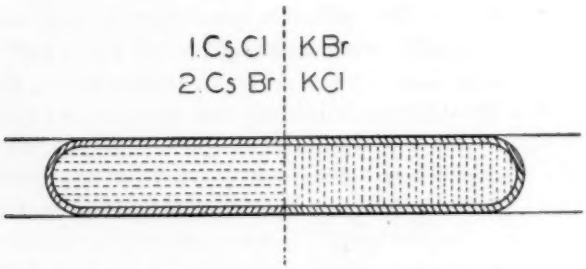

FIG. 6. Showing arrangement for testing mobility of chloride and bromide ions.

days, was shifted slightly more towards the *B* pair than at 477°C. The behaviour of this reciprocal system appears to be very similar to that reported by Tubandt and Reinhold[9] described above for the Ag_2S–CuI and Ag_2S–Cu_2Se reactions.

Since both of the common cation pairs associated with the KBr–CsCl reaction form stable solid solutions it is perhaps not unreasonable to propose the hypothesis that the chemical reaction occurs and the solid solutions form by an exchange migration of the anions while the cations maintain their positions except for the relatively small adjustments required by the entering anions. This idea was tested by arranging the *R* pair and then the *B* pair as shown in Fig. 6. After heating for 459 hours (nearly 3 weeks) at 400°C. small amounts of powder were removed from each side of the boundary and tested by the index

of refraction method which proved to be a very sensitive method for detecting small crystals of solid solution of KCl and KBr. The results showed that in the case of the *R* pair there was a solid solution KBr and KCl on the right and in the case of the *B* pair a solid solution of KCl and KBr on the right. No evidence

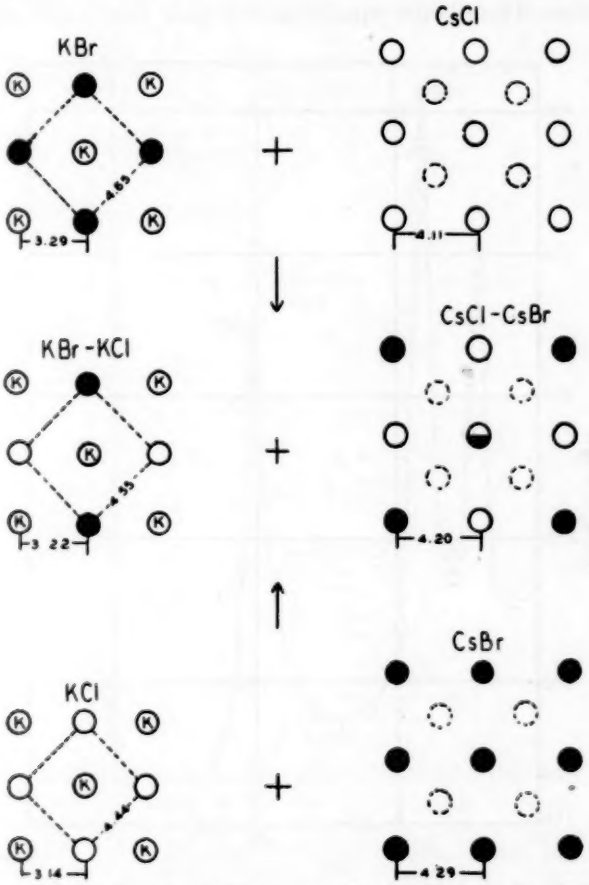

FIG. 7. Showing the ion arrangement in the *R* pair and in the *B* pair of the reciprocal system KCl+CsCl⇄KCl+CsBr. The black circles represent bromide ions, the open circles chloride ions and the dotted circles cesium ions below the plane of the paper.

for any potassium ion migration was obtained. These results could not be confirmed by the x-ray method since a migration of at least 2 or 3 mm. by the anions would have been required.

A possible and perhaps reasonable mechanism for the KBr–CsCl reaction is represented in Fig. 7. The arrangement of po-

tassium and halide ions has been represented in Fig. 5. The arrangement of the ions in CsBr and CsCl is different. Each kind of ion is arranged on a simple cubic lattice (space pattern) and the lattices interpenetrate in such a way that 8 halide ions surround each cesium ion and each halide ion is surrounded by 8 cesium ions. The planes parallel to the face, the (100) family of

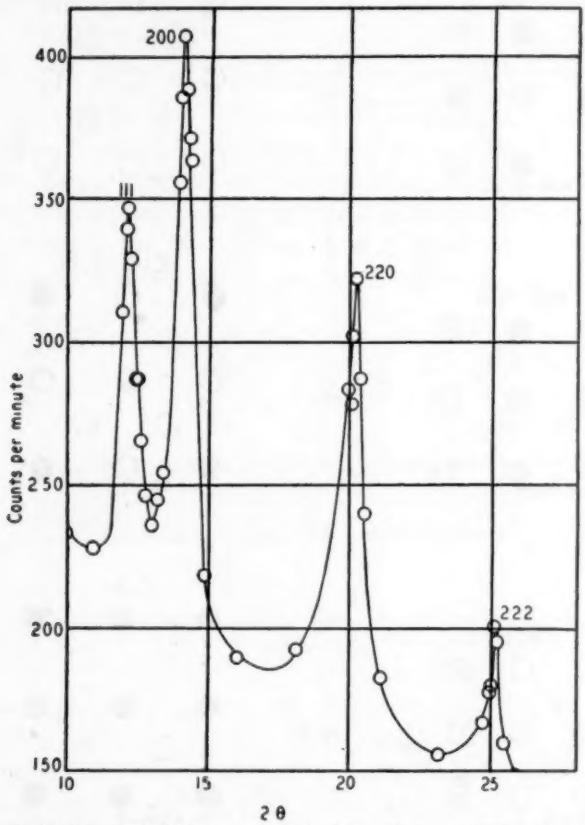

FIG. 8. NaCl intensities by means of the Geiger-Müller Counter.

planes, are alternately all cesium and all halide ions. If the CsCl crystal be turned 45 degrees about an axis perpendicular to the paper and then be placed above the KBr in such a way that the cesium ions (dotted circles) fall above the potassium ions, the halide ions would appear to be conveniently arranged for a migration exchange which could bring about the reaction.

$$KBr + CsCl \rightleftarrows KCl + CsBr$$

(For convenience in drawing the reaction is represented as occur-

ring to the extent of 50 per cent when starting with either the *R* or *B* pair, the middle section of Fig. 7 representing the solid solutions.)

In an effort to get some idea of how this might come about the intensities of several lines in the interference patterns of a series of KCl–KBr solid solutions were measured by means of the

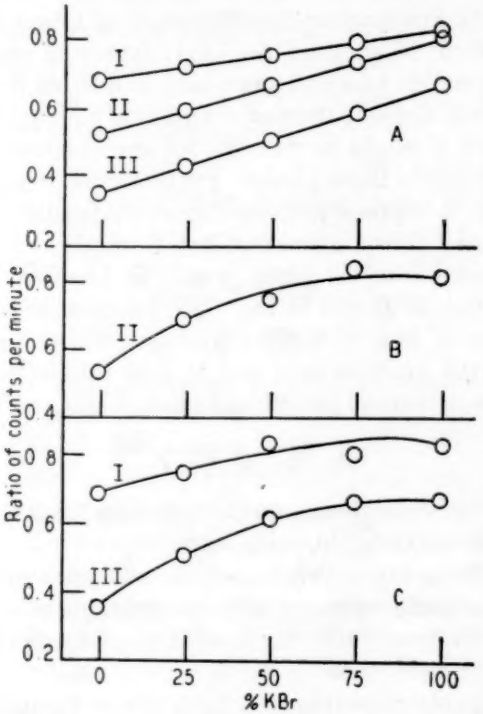

FIG. 9. Showing the relative intensities of the KCl–KBr solid solution interference lines as measured by the Geiger-Müller Counter. Curve I shows the intensity ratio between the 220 line and the 200 line, curve II between the 222 and 200 and curve III between the 222 and 200. In *A* the average calculated ratios are shown and in *B* and *C* the observed.

Geiger-Müller Counter.[32] The Geiger-Müller Counter was calibrated by first measuring the intensities of several important NaCl lines the results of which are shown in Fig. 8. It is of interest to compare this curve with the one obtained by Bragg,[12] using an ionization chamber which has been reproduced in many

[32] The Geiger-Müller tube is an extremely sensitive detector of x-ray beams Its conductivity changes greatly when an x-ray beam strikes it and the current can be magnified manyfold by a radio amplification circuit. The Geiger-Müller counter can be made hundreds (perhaps thousands) of times more sensitive than an ionization chamber. See H. Geiger and W. Müller, *Phys. Zeits.*, *29*, 839 (1928).

texts in elementary physical chemistry. The results of the intensity measurements of the KCl–KBr solid solutions are shown in figure 9.[33] These curves indicate that the intensities of the 200 and 220 interference lines were found to be relatively less than that of the 222 line. These three lines are produced respectively by the (100), (110) and (111) families of planes (see figure 5) and are the first even ordered[34] lines to be found in the interference pattern. Now, since the (111) family of planes are alternately all halide ions and since each halide ion lies in several of these planes, the ions themselves making equilateral triangles in the planes, it might be possible for the entering halide ions to spread through these planes. Furthermore it might not be unreasonable to suppose that the ions of these planes, which are made up of half chloride ions and half bromide ions (in the case of an equimolar solid solution), would fit together better than the ions in the (100) and in the (110) families of planes which are made up of half potassium ions, one-fourth chloride ions and one-fourth bromide ions and that if this were the case a relatively more intense interference line might result.

Summary

1. Since 1885 it has been known that chemical reactions occur between substances in the solid state.

2. Until the x-ray crystal analysis method was developed, following the course of many of these reactions was difficult.

3. The velocity of such reactions at room temperature is, for the most part, very slow.

4. At temperatures within 100°C. or less of the fusion temperature the velocity often becomes quite appreciable.

5. Because the reaction velocity is much greater at first and becomes much slower with time it has been suggested that the reaction begins in a very thin "Reaction Layer" and that the velocity of the reaction becomes less as this layer becomes thicker.

6. Many of the 60 reciprocal reactions that can be set up for the common halides of lithium, sodium, potassium, rubidium and cesium show a very pronounced tendency to proceed towards the salt pair of balanced mass, the pair that has the heavy

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[33] M. A. Broun, A Study of KCl-KBr solid solution interference lines by means of the Geiger-Müller Counter, B.S. Thesis, St. Louis University, 1941; John McCann, A Study of KCl-KBr solid solution interference lines by means of the Geiger-Müller Counter, B.S. Thesis, St. Louis University, 1941.

[34] In the Bragg equation n equals 2.

cation united with the heavy anion and the light cation united with the light anion.

7. Some of these reciprocal reactions form an equilibrium at temperatures well under the fusion point.

8. One of these, the reaction

$$CsCl+KBr\rightleftarrows KCl+CsBr$$

has been found to follow the Law of Mass Action at approximately 100°C. under the fusion temperature.

The author is indebted to Dr. H. L. Link and Dr. Wm. Vogt for some hitherto unpublished material included in this report.

NOTES FROM A MATHEMATICS CLASSROOM

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101. Mensuration Formulas of Solid Geometry. An examination of textbooks in solid geometry shows that they have changed less in the last twenty years than those of any other high school subject. Many newer type tests have been added, and that represents the total change. Some theorems have been moved from the text proper to the appendix, but such changes reflect merely the author's likes and dislikes.

Recently I have been examining some outlines of the course as taught by various teachers. Outlines presented by examining boards or courses of study give little indication of what is actually taught since they merely give a list of theorems. To learn what really happens in a class I like to see a day by day outline showing that on April 14, for example, the recitation hinged on theorem 5 and ex. 1 to 5; on April 15 a ten minute test was given and followed by a proof of theorem 6 and ex. 9, 14, and 16; on April 16 the class studied dihedral angles and sections 83 to 89. Such outlines are truly valuable. I would strongly urge every novice to keep such a record in every class for a few years. And every school should have a file of such outlines for other teachers to consult.

The outlines of this type which I have seen for solid geometry all have one favorite phrase to describe the proofs of the mensuration formulas: *treat informally*. Hence I shall discuss my own idea of an informal treatment of these formulas.

There is a theorem (call it Theorem A) "two prisms are congruent if the three faces that include a trihedral angle of one are congruent respectively to the three faces that include a trihedral angle of the other, and are similarly placed." This theorem is never needed in the proof of any other theorem, and is never used after being proved. Later a corollary of this theorem is actually used, namely "two truncated prisms are congruent under the conditions stated in the theorem." Theorem A should either be omitted or it should begin "two truncated prisms, etc." Further, the corollary is used only *once*, namely, to prove Theorem B: "An oblique prism is equivalent to a right prism whose base is a right section of the oblique prism and whose altitude is equal to a lateral edge of the oblique prism." Next we note that Theorem B is used only twice; (a) to prove Theorem C "A parallelopiped is divided into two equivalent triangular prisms by a plane passed through two diagonally opposite edges," and (b) to prove Theorem D: "The volume of any parallelopiped equals the product of its base by the altitude." Further, we note that Theorem C is used to prove Theorem E: "The volume of a triangular prism equals the product of its base by the altitude."

The non-use of Theorem A and the slight use of Theorem B suggest that an informal treatment of the entire sequence could be reduced to the following:

Theorem D resembles the theorem which states that the area of a parallelogram equals the product of its base and altitude. This is usually proved by cutting off a triangle (or trapezoid) from one end and placing it at the other end. A teacher can show by a cardboard or wooden model that Theorem D cuts off a chunk from one end of the parallelopiped and places it at the other end. The operation needs to be performed only once for a parallelogram but two such cuttings are needed for the solid since the latter may slant toward the east as well as toward the south. A wood-working shop can make such a model. I have one in which pegs fitted in holes keep the pieces together so that the resulting solids can be passed among the pupils for dissection and assembling.

Likewise a wooden model can easily be made for Theorem E. The base is a triangle, and the lateral edges are oblique to the base. A plane perpendicular to an edge cuts off a part which can be shifted from one end to the other, making a right triangular prism.

After the pupils have handled the models, we can say to the class, "To prove these facts rigorously we need Theorems A, B, etc. Those of you who are interested may read the proofs in the book. Let us proceed to use Theorems D and E." A single class period should be enough for this treatment.

102. Theorems that Use Limits. When the topic of pyramids is reached we have Theorem F: "Two pyramids having equal bases and equal altitudes are equal." This theorem is used oftener than Theorems A or B, and is needed to prove the theorem about the volume of triangular prisms. To avoid the use of limits in proving Theorem F, use is made in some texts of *Cavalieri's* Theorem, which can be proved only by using limits. My informal treatment of Theorem F consists in showing the similarity between it and the theorem which states that triangles having equal bases and equal altitudes are equal. After seeing the similarity we postulate the theorem about the pyramids.

So far, the solids have not been bounded by curved surfaces. When we reach the lateral area and volume of a circular cylinder, I dismiss solid geometry for a day and discuss calculus. I do not wish to give an introduction to the theory of limits; in fact, I wish to have as little as possible to do with limits. I wish merely to justify to the class our omission of work on limits and to justify the assumption of certain formulas.

After drawing the curve $y=10x-x^2$ I suggest we find the area between it and the x axis. We draw the ordinates at $x=1$, 2, 3, etc., and consider each part as a trapezoid and find the approximate area. For a second and better approximation we can draw the ordinates at $x=\frac{1}{2}$, 1, $1\frac{1}{2}$, 2, etc., and sum the twenty trapezoids. For a still better approximation we can draw ordinates at $x=\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$, etc. To do this would require much precious time, but the class can see the possibilities. We can thus get a sequence of numbers each of which is an approximation of the area. If there is a number such that we can get as close to it as we wish by taking enough trapezoids, then that number will be the area. It is the business of calculus to find that number. Likewise, a volume of a solid bounded by curved surfaces can be found by approximations.

It is easy for a teacher to talk too much; once started, the teacher must discipline himself against the tendency to say more than is necessary. In the present situation I finish by saying that the methods of calculus will derive the formulas much more easily than the methods in our textbook; hence we can

profitably assume the formulas for solids having curved surfaces, and devote our time to other work.

When we reach the theorem about the surface formed by revolving a segment of a line about an axis, I state that the only use we can make of this theorem is to prove the formula for the area of a sphere or a zone. Since calculus can do this easily, we omit that theorem. And when we reach the theorem about the volume formed by revolving an isosceles triangle about an axis, I state that the only use we can make of this theorem is to prove the formula for the volume of a spherical sector. Again calculus does this more easily. My *informal treatment* is thus limited to about two minutes of time in class. However, we do take all the time that may be necessary to prove the formula for the volume of a spherical segment. The latter involves only algebra and is included as part of a maintenance program in algebra. I note that this valuable work is often omitted by those who spend much time on limits.

A final remark about Theorems A to E. Before these theorems are reached in the textbook, a class can spend an interesting day on the question: What would you need to know about such solids to be able to say that they have equal volumes? Is it enough to have equal bases? Would you be satisfied with equal but not congruent bases? What other conditions are needed if the edges are oblique to the base? This discussion is similar to the question in plane geometry: What is the least you need to know about two triangles to be able to say that they are congruent? What is the least you need to know about two quadrilaterals to be able to prove them congruent? How little will you be satisfied with as a hypothesis? Are you selfish and demand a great deal, or are you a genius who needs little?

SILVER BURDETT HAS A BIRTHDAY

Silver Burdett observes a gala occasion this year as the company reaches its sixtieth birthday. Edgar O. Silver, the founder, would scarcely recognize the offspring of the humble publishing business he set up in Boston in 1885. His list of one item, *The Normal Music Course*, has grown and expanded to include basic texts in the major subjects of both primary and secondary school levels, and Silver Burdett Company has emerged as one of the country's leading textbook publishing houses with offices in New York, Chicago, and San Francisco.

TEACHER-TRAINING IN AERONAUTICS AND IMPLICATIONS FOR HIGH SCHOOL TEACHING

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I

The damage done by a few planes with comparatively light loads of explosives—as we think of aerial attack today—at Pearl Harbor on December 7, 1941 caught the public schools as well as the teacher-training institutions unaware that the air age had arrived and unaware that we had to participate in it, make its instrument, the airplane, our servant or perish. Just as we tooled our factories to turn out a quarter of a million planes during the last five years, so did some 170 teacher-training institutions set up programs for teachers in aeronautics and we now have thousands of aeronautics courses in our high schools and aeronautics materials have been introduced into most areas of study from the primary grades through the high school. The military emergency was met.

Of necessity, the first job was hastily improvised. If ever teachers and students learned together it was in aeronautics courses. This paper is an attempt to describe how one school met the immediate challenge and how its teacher-training program has evolved during the succeeding years, with some implications drawn from that experience for teaching aeronautics in the high school.

During the summer of 1942, two non-credit, two-week courses in the teaching of aeronautics were offered for teachers, plus a demonstration course in aeronautics in the University High School. Two mathematics teachers collaborated in the high school course and various departments of the University were called upon to furnish lecturers on such subjects as global geography, navigation, aerodynamics, instruments, and meteorology. More than 100 teachers took these first two short courses.

In the fall of 1942 the Extension Division added a correspondence course in the teaching of aeronautics. In the summer of 1943 the short courses were offered again and about fifty more teachers were reached. By this time the larger part of the teaching was done by members of the College of Education, and the students did somewhat more than just look and listen, but still did not receive credit.

Obviously the type of training offered in these short courses was inadequate. Complaints were heard that the early enthusiasm for aeronautics was waning. Students found the subject either too technical, too bookish, or too dull. Some schools could not get sufficient enrollment to continue the work, even though state programs were beginning to appear, and most educators recognized a permanent need for teaching at least some aspects of aeronautics. One instructor reported that he had the students read the chapter, answer the questions at the end, correct the answers, and then go on to the next chapter. This was an all-too-common technic in the aeronautics class, and probably one of which most teachers were guilty at some time.

To meet the need for better training a more comprehensive course was planned and offered during the summer of 1944, and was repeated with some modifications during the past summer. In planning the course the people in charge made the following assumptions:

1. A good teacher of aeronautics should have a reasonable knowledge of several different areas in the field—aerodynamics, navigation, and meteorology, particularly, and to a lesser extent communications, civil air regulations, engines, structures, and physiology.

2. In addition to knowing the subject matter, the teacher should see the relationships of the different areas to each other and should not ride a hobby in his course so that important aspects would be slighted or ignored.

3. He should have as many experiences as possible with the different areas, so that he could teach them concretely and vitally to his pupils.

4. He should be able to apply the best thought about science teaching to teaching aeronautics.

5. He should have an understanding of the social implications of the airplane, of the impact it has already had on warfare and on our social structure, and what some of the probable future trends will be.

6. He should have some familiarity with the growing literature in the field.

Next a survey was made of the resources available for offering such a course. The university is building a large airport and making plans for a rather comprehensive program of aeronautics research and instruction. Work has already started in some areas. Where expert help was needed, there were a number of

experts in various fields to call upon. Two small private airports were at the edge of town. Chanute Field was only minutes away. The CAA, United Airlines, and the State Department of Education offered to cooperate.

Because of the recommendations being made throughout the country that flight experience be a part of the high school course as laboratory work, it was decided to offer eight hours' dual flying instruction to members of the class without extra fee. Many, probably most, aeronautics teachers have had little or no experience in the air. The following criteria were set up for eligibility:

1. Total number eligible for flight would not exceed twenty.
2. The student should have taught aeronautics during 1943–44 or be assigned to teach it in 1944–45.
3. The student should not previously have had more than eight hours' dual flight instruction, or have soloed. Any flight time previously logged was to be deducted from the eight hours. Twelve class members qualified for the full eight hours.

Finally, course plans were left sufficiently flexible to meet student needs, and to take advantage of student talent.

The class met from eight until eleven four days a week, with an additional four hours worked in at various times in addition to their flight experience. Four hours' undergraduate credit or one unit of graduate credit was given for the course. Arrangements were made in a seminar in secondary education for experienced teachers to work on individual problems in aeronautics in addition to their work in the teachers' course. Five students took both courses.

A brief survey made during the first meeting of the class indicated a wide range among the class members as to background, preparation and teaching experience. Some of the members had never previously taught aeronautics, others had had from one to three years' experience, and one had taught in a CPT program. Some members of the class had from one to three CAA ground instructor's certificates, and one member had five. Questions on the areas in which the students felt most and least competent demonstrated that practically nothing could be omitted or treated lightly without failing to meet the needs of some members of the class.

The survey also indicated that there were considerable student resources in various areas and plans were made to utilize these. One member of the class had been teaching aircraft en-

gines in a high school shop which had more than $150,000 worth of engines and equipment. Another displayed genius at developing effective demonstrations with such things as nails, bits of board, wall board, mailing tubes and the like. Another turned out to be a communications expert. Two others prepared such a good radio program on civil air regulations that a recording was made of the material so that it might be used for classroom instruction later.

The class was on the air three hours a week, and all students participated at one time or another in these programs. This did offer some handicap to the organization of the work as many aspects of aeronautics simply cannot be made to sound sprightly over the air, and with the class meeting many other hours during the week it was necessary to preserve some continuity in the broadcasts.

The required activities for the class were as follows (some of these were done singly, some in pairs, and some in larger groups):

1. All members of the class, working in pairs, took weather observations with the simple equipment available in the average high school, or improvised from simple materials, for a period of one week and reported these observations to the class as station models and sequence reports.

2. Again working in pairs, all members of the class were responsible for bulletin board displays for one week. Several hundred square feet of bulletin board were available and some of these displays were excellent.

3. Each student was required to assemble a scrapbook or to organize a file of bulletin board materials from sources of free materials, newspapers, magazines, pamphlets, photographs, etc.

4. Each student was responsible for the construction of a major item of equipment or for presenting three simple demonstrations. Equipment constructed included three types of anemometers (the regular ones begin at $60.00); wooden models to illustrate valve action, a two-cylinder opposed engine, and five-cylinder radial engine; clinometer; a large device for illustrating, variation and deviation; a number of demonstrations of stability, measuring cloud height with simple apparatus, centrifugal force, conservation of angular momentum, Bernoulli's principle, and others.

5. Each student was asked to participate in at least one radio program. This participation ranged from a round-table discus-

sion by half the class to three lectures on engines by one member.

6. Each member of the class was asked to make out detailed plans for one major unit of work. (Navigation, meteorology, communications, aerodynamics, etc.) These were to include a statement of objectives for the unit, reference materials, visual aids, bulletin board materials, tests, and complete lesson plans showing how and where these various materials would be used.

7. Each member of the class was asked to hand in a complete outline of a year's work in aeronautics. The better ones included topics, objectives, visual aids, bulletin board materials, reference materials, tests, and skeleton plans.

8. Each member of the class learned to identify 15 current military planes after a one-second look at the silhouette of the plane when projected on a screen by an opaque projector.

9. Each member of the class was asked to qualify for one CAA ground instructor's rating for which he had not previously qualified. About three-fourths of the members of the class met this requirement.

10. All members of the class were asked to turn in each week three annotated references of books or magazine articles which would be useful to pupils in understanding aeronautics or which could be used as motivation material. They were particularly urged to use current materials as the field is advancing so rapidly that much textbook information rapidly becomes dated. They were also directed to use magazines of general interest at least as much as the more technical journals. These reports were collected on Friday, organized, duplicated, and returned at the first meeting of the next week. About 250 articles and books were thus reviewed.

11. All students were asked to evaluate the bulletin put out by the office of the State Superintendent of Public Instruction called *A Program of Aviation Education for the Schools of Illinois*. They were also asked to evaluate their course.

Other activities besides those mentioned as required in which from one to all members of the class engaged included the following:

1. A professor in the Department of Physiology had been doing some research in high-altitude flight, simulating altitude with a low-pressure chamber made from a hospital bed-sterilizer. This teacher, in addition to giving several lectures to the class, used some members as guinea pigs, attempting to induce

stomach cramps by simulating rapid ascent to high altitude. All members of the class used the chamber for "flights" from 10,000 to 35,000 feet. This experience included the use of oxygen masks, telephonic communication to observers, observations of rate of climb indicator and sensitive altimeter, and use of meteorological instruments to determine temperature and dew points at various altitudes. The class also witnessed some demonstrations of the effects of low pressure and oxygen lack in the physiology laboratory.

2. One day was spent inspecting CAA and United Airlines facilities at the Chicago Municipal Airport, and in discussing the future of aviation and aviation education with United Airlines engineers and School and College Service personnel.

3. The Physics Department presented a number of interesting demonstrations for the class.

4. The Mechanical Engineering laboratory exhibits of various types of airplane engines were available for study for our group.

5. The Industrial Education Department of the High School and College of Education cooperated with students in the preparation of projects.

6. The class viewed about twenty film strips as a group, and many others as individuals or small groups. The class as a whole witnessed about thirty films and aided in the evaluation and selection of additional films for the University Visual Aids Service.

7. One member of the class soloed at the end of his eight hours, and several members soloed with some additional hours purchased by themselves.

8. One morning was devoted to giving and taking the various tests outlined in the book, *Are You Fit to Be a Pilot?* This was followed by a discussion of how the book and the tests could be best used in the high school class.

9. Guest speakers heard by the class, in addition to those already mentioned, included an assistant state superintendent of schools and an educational representative of a large airline.

Many topics were covered during the course. Time was divided into three fifty-minute lectures—because of the radio broadcast—followed by two hours of laboratory work three days a week. The laboratory sessions were used for quizzes, discussions, demonstrations, visual aid materials, weather reports, further lectures, problem solving, work on projects and

units, reading, and short field trips. Fridays were used to catch up on loose ends hanging over from the previous week or for extension of the laboratory work as was necessary. The extra four hours were spent usually in smaller groups in preparing radio programs, reports, demonstrations, bibliographies, viewing additional films and film strips, and the like, according to individual or small-group interests.

It was necessary to build up a subject-matter background for some members of the class, new to the field, although few of the members felt thoroughly competent in any area. Along with building up a subject-matter competence it was necessary to develop teaching technics. Experiences were pooled as much as possible and most members had something unique to contribute. Lectures were given on social implications of the airplane for war and peace, objectives of aeronautics education, physiology of flight, airplane engines, navigation, services of the State Department, services (educational) of the airlines, aerodynamics, instruments, and meteorology. Groups discussed physical principles involved in aeronautics, parachutes, communications, civil air regulations, map projections, and flying experience. None of these received a completely adequate treatment but meteorology was most slighted.

Perhaps an undue proportion of laboratory time was devoted to viewing films and film strips, but there were two reasons for this—to give aid in learning subject matter to those who needed it, and to give all students a chance to select films and film strips for instructional purposes on the basis of what they had seen and evaluated rather than from possibly misleading catalog descriptions.

The students were enthusiastic about the class if anonymous evaluations made at the end of the term may be accepted. The chief criticisim was not that too much was attempted, but rather that a more thorough treatment should be given and that more time should be devoted to the work. The general opinion was that the course was helpful in preparing teachers of aeronautics or in improving instructional procedures of those already teaching. The class also agreed that both quantity and quality of work were of graduate calibre. Most members of the class rated flight experience as the most valuable activity, and said that it integrated theory for them and gave meaning to much of the other material which could never have been obtained vicariously.

Perhaps the course can be criticized because it did not follow majority opinion that aeronautics materials should be integrated into existing courses and that the need for separate courses no longer exists. The writer believes that there is still room and need for both types of aeronautics education. Various estimates put the number of student pilots during the next few years as high as 5,000,000. The CAA is relaxing its restrictions to encourage flight. The philosophy of protecting both the public and the pilot is being modified to protect just the public, and the public not quite as well as before. The number of private planes is expected to increase from tens of thousands to perhaps five hundred thousand. Remember that conservative Wall Street bankers thought Durant crazy when he predicted shortly after the turn of the century that sometime 500,000 automobiles would be built in a single year. It is proposed to spend a billion dollars for airports and airstrips so that the number now in existence will be doubled and every town and city of 2,500 population or more will have flight facilities available. Unless pilots understand the limitations of their planes and of themselves we may find the airplane killing more people in proportion to its numbers than has the automobile. Ground instruction must be offered some place. We have partially accepted a view that not only ground instruction, but also flight instruction, should be at public expense in the CPT programs. If it is to be widely disseminated among the population, then the public schools are in the most favorable position to give it—if they have trained teachers available.

A valid case may be argued for teaching aeronautics as a science. This objective has been accepted by the state programs so far issued, and the flight experience recommended in all the programs has been laboratory experience in a science rather than flight instruction to prepare one for personal piloting. Certainly the aeronautics course offers opportunities for teaching scientific principles and scientific method in a context so full of interest to many students that they master these concepts in the aeronautics courses when they have failed to master them in the traditional science courses. Likewise many opportunities are offered to make concrete applications of much of elementary algebra and plane geometry.

Social implications were neither denied nor ignored. Rather, it was accepted that our democracy has an opportunity for once, through applying mathematics and science, to achieve a higher

degree of social control over an instrument of almost infinite possibilities of social change than it has ever had before or is likely to have again.

II

What is the significance of the descriptive material in the first section of this article for the teacher of aeronautics on the high school level? If there is any single generalization to be made, and this one has been tested on five different high school groups in two different schools, it is that the methods which were used with the teachers' group are also effective methods for use with high school classes. Some of these are listed.

1. The recommendation of the state programs that flight experience be offered to students is undoubtedly a sound one. While none of the writer's classes has had this instruction as a group, individuals from each class have taken lessons while taking the course. This flight experience has enabled them to offer much to group discussions and has also made theory more intelligible to them.

2. The high school teacher should endeavor to locate and capitalize on student talent. Probably no teacher can be an expert on all phases of the subject and he will find in every class that there are some students who know more about some aspect of aviation than he does. It may be that these students will be people who have had long experience building models. Get these students to build demonstration equipment for the class. Possibilities are models with movable control surfaces, wind tunnels, wing sections, and models for testing purposes. The recent CAA sponsored book, *Demonstrations and Laboratory Experiences in the Science of Aeronautics*, should offer numerous suggestions for putting the young craftsman to work. It may be that some of the pupils have collected files or pictures which will make interesting bulletin board displays. One boy in our school has an almost complete set of pictures, specifications, and performance data on all the army and navy planes since the first one was purchased from the Wright Brothers. Or there may be boys in the class who have worked around an airport. One boy in the writer's class had been doing this for about three years. He could bring a handful of fabric, rivets, nuts, cotter pins, and other small parts into the classroom and give an authoritative and fascinating talk for any length of time up to a whole period. Amateur photographers can take pictures and make slides which can be useful to the class.

3. Survey the resources of the school and community for possible sources of pupil experiences. The mathematics teacher in charge of aeronautics courses will get much help from the science department, both in equipment and suggested demonstrations and experiments. Shop teachers are usually glad to assist students in building equipment. Does the town have an airport, an airplane factory, a glider project, a weather station, any airways beacons or radio equipment? If any of these can be found the skillful teachers will use them. Even the junk yard should not be ignored as a possible source of cheaply obtained airplane parts, or as a source of cheap materials from which equipment for demonstrations may be constructed.

Is there a branch of the Civil Air Patrol in the town? It may have instructional equipment available, not yet available to the schools which may be borrowed. Excellent motion pictures, which will be of interest to students, are often shown at CAP meetings. The branch in Champaign gave dual flying instruction to the honor student in one high school class.

4. There is an increasing library of excellent films and film strips available covering all aspects of aeronautics. The best concrete illustration of the air mass theory which the writer has seen was a Disney-prepared army film in color on the subject.

5. A sling psychrometer and a mercury barometer, instruments found in almost all physics laboratories, together with other apparatus which can be improvised, will enable students to take weather observations. In lieu of a mercury barometer, a sensitive altimeter obtainable from army surplus equipment may be used and is quite accurate. These observations should be put in the form of station models and sequence reports after appropriate corrections are made. These may be put on the blackboard or bulletin board each day by a pair of students. Using this device, students soon learn to read weather maps and sequence reports, to identify cloud forms, and to master much of the vocabulary of meteorology needed by the pilot. If there is a weather station close, pupils will be interested in checking their observations against those of the station from the weather maps, so far as the two are comparable considering necessary differences in time of observation.

In introducing this activity it may be worth while to present it to the students as a problem. After some study of weather observations, have them prepare plans for taking all the observations necessary for preparing station models and sequence

reports. These different plans may then be brought together in the class, discussed, and the best selected for use. Additional equipment needed can then be made by students.

6. Students are usually fascinated by the tests outlined in *Are You Fit to Be a Pilot?* They like to give them and to take them. If this book is used, the teacher should organize the work carefully, and should try to have at least three rooms available so that most of the tests can be given simultaneously. Students should be thoroughly familiar with the meaning and method of administration of the particular test or tests they are giving. Results may be recorded on a mimeographed sheet, and at the end of the testing period each student should report briefly to the class the significance of his particular test. Aeronautics classes also enjoy giving these tests to other groups. This year the class tested two introductory science groups, some of the faculty, and two members of the University Department of Physiology.

Occasionally the tests will have interesting by-products. One student discovered that he had extremely poor vision. He consulted an oculist. Soon it was discovered that his entire family needed glasses. All had had such poor vision that none had seemed abnormal. On other occasions it has been recommended to students who have had an abnormally high pulse rate on the circulatory efficiency test that they consult their personal physician. On two occasions the physician recommended a less strenuous physical education program for these youngsters.

7. Both technical and general magazines are filled with pertinent and useful information. Teachers will find it worth while to set aside a little time each week for brief reports on some of these articles. Other articles he will want to assign for general reading. Sometimes articles will appear which he will wish to keep for permanent use. Examples of these were the series on map making and the series on aerial navigation in *Life*.

8. The writer does not believe that technical and mathematical phases of aeronautics should be avoided. When carefully taught the technical concepts can be mastered by most pupils. We hear a great deal of criticism about the teaching of mathematics, yet when opportunities arise for making that mathematics functional in another subject, the critics are again vocal and tell us that we are making the subject too dull, too difficult. The writer believes that the formula and fundamental notions about variation are highly pertinent to many

aspects of aeronautics, particularly aerodynamics. He believes that we have tended to neglect the use of symbolism as a tool to facilitate thinking in the secondary school. The most effective way he has found of making a final statement of Bernoulli's principle (laboratory demonstrations and films having been previously used) is to write down the formula

$$\frac{V^2}{2g}+\frac{p}{w}+z=k$$

and then ask the class, after being sure that they understand the symbolism, if v increases, g, w, z, and k remain the same, what must happen to p?

A similar use is made of lift, drag, and horsepower formulas to help teach concepts of why an airplane performs differently under different conditions, and why increasingly higher speeds require such tremendous increases in power. The teacher of aeronautics can find examples of many types of variation; the teacher of mathematics can find concrete illustrations of many types of variation—direct and inverse, square root, square, and cube, and even as the three-halves power—in the elementary aerodynamics formulas.

In a fairly good class, the writer thinks that it is worth while for the teacher to demonstrate, with as much pupil participation as he can get, how the axioms of algebra may be applied to derive some of the more complicated formulas, i.e., how the deductive method of thinking is still useful in physical science. Likewise many theorems of plane geometry may be applied, and some proofs may be worked out in navigation. Since one of the criticisms of our high school curriculum is its fractionalization, the lack of relation of its various parts, it seems a pity not to take opportunities to use materials and methods in one field when they will shed light on another.

A few of the many possible ways of vitalizing aeronautics instruction have been indicated. The ingenious teacher should think of many others. One which occurs to the writer, but which he has not tried, would be the writing of scripts and the making of recordings by pupils, similar to those put out by the School and College Service of United Airlines. This might make an excellent summary activity for a unit. Another would be the selection of passages from anthologies of aviation stories for the purpose of letting pupils apply their knowledge of principles to

finding errors in the concepts of the early writers. Sir Arthur Conan Doyle, for instance, has some beauties.

Any teacher willing to put forth a little extra effort can have a good aeronautics course, and can probably learn much more than any of his pupils in the process.

THE QUIZ SECTION

JULIUS SUMNER MILLER
Chapman College, Los Angeles 27, California

Quiz exercises, like the circus, have an appeal for persons aged 8 to 80. To satisfy this quest we are placing on trial a new department entitled THE QUIZ SECTION. *There will be some ten or a dozen simple questions or statements, some true or false, some multiple-choice, some neither. The science involved is to be of an elementary nature designed to arouse the interest of the younger readers. It is hoped that teachers from the grades on up will find the department pedagogically useful. Contributions are invited from all who are interested. It is especially urged that the young readers contribute. Acknowledgment will be made. Teachers are urged to try this out on their classes. Send answers and new questions to the editor of this department.*

1. When you pull the plug in your bath tub, does the water run down faster if you stay in the tub or if you get out?
2. You can mix a quart of alcohol and a quart of water and have less than two quarts of the resulting mixture. (T or F)
3. Fungi are plants without chlorophyll. (T or F)
4. A man traveled from *A* to *B* at 20 mph. and returned at 30 mph. What was his average rate?
5. Only those stars of the sixth magnitude or brighter are visible to the unaided eye. An observer can see approximately how many at one time . . . 250, 2500, 25,000, 250,000, 2,500,000?
6. Solar eclipses occur precisely at new moon. (T or F)
7. Identify these time intervals: 12 hours 26 minutes; 23 hours 56 minutes; 27 and ½ days.
8. Can a mirage be photographed?
9. A tuning fork of frequency 256 is struck and heard at a certain point in one second. When would a fork of frequency 512 be heard at the same point?
10. For maximum short-circuit current how should a group of similar cells be connected?

ANSWERS TO THE QUIZ SECTION

1. Faster if you stay in; 2. T; 3. T; 4. 24 mph.; 5. 2500; 6. T; 7. Rise and fall of the ocean tides; rotation of the earth; rotation of the moon; 8. Yes; 9. Same time; one second; 10. Parallel connection.

You may disarm the hands but not the brains of a people, and to know what should be defended is the first condition of a successful defense.—JAMES RUSSELL LOWELL.

EASTERN ASSOCIATION OF PHYSICS TEACHERS
ONE HUNDRED FIFTY-NINTH MEETING
Belmont High School, Belmont, Massachusetts, Saturday, March 31, 1945

9:45 Meeting of the Executive Committee.
10:00 Welcome to Belmont
Mr. Mark R. Shibles, Superintendent of Schools, Belmont
Welcome to Our Building
Mr. George Higginbottom, Principal, Belmont High School
10:10 Report of the Secretary
Report of the Treasurer
Report of the Auditor
Report of the Nominating Committee
10:25 "How Fast Sound?"
Miss Anna E. Holman
10:30 "Some Unusual Magazine Articles"
Mr. Kenneth L. Goding
10:35 "The Requirements to Teach Physics," the A.A.P.T. Report.
Mr. Homer W. LeSourd
11:00 "Fifty Years Ago"
Mr. Fred R. Miller
11:10 "Atom Smashing and Its Modern Applications"
Assistant Professor Robley D. Evans, Massachusetts Institute of Technology
12:00 "One Way of Teaching Acceleration"
Vice-President Clarence W. Lombard
12:30 Luncheon
2:00 "Applications of Low Frequency Currents in the Practice of Podiatry"
Dr. Harvey Atkinson, President of the Massachusetts Chiropodists' Association and Member of the Board of Directors of the Massachusetts Academy of Podiatry.
2:40 Two Talkies on "Sound"

Officers:

President: Hollis D. Hatch, English High School, Boston, Mass.
Vice-President: Clarence W. Lombard, Hyde Park High School, Hyde Park, Mass.
Secretary: Carl W. Staples, Chelsea High School, Chelsea, Mass.
Treasurer: Albert R. Clish, Belmont High School, Belmont, Mass.

Executive Committee:

Ralph W. Houser, Roxbury Latin School, West Roxbury, Mass.
Lawrence Harris, Boston Trade School, Boston, Mass.
W. Roscoe Fletcher, North High School, Worcester, Mass.

BUSINESS MEETING

The following were elected to membership in the Association:
Leo Lapidus, Somerville High School, Somerville, Mass. Active.
Philip Gordon Johnson, Memorial High School, Middleboro, Mass. Associate.

Report of the Nominating Committee

The Nominating Committee submitted the following names: President:

Ralph H. Houser, Roxbury Latin School, West Roxbury, Mass. Vice-President: George A. Cushman, Hyde Park High School, Hyde Park, Mass. Secretary: Carl W. Staples, Chelsea High School, Chelsea, Mass. Treasurer: Albert R. Clish, Belmont High School, Belmont, Mass.

EVERETT J. FORD, *Chairman*

The above were elected officers for the ensuing year.

After the meeting it was learned that Mr. Houser and Mr. Cushman found it impossible to serve as president and vice-president respectively, and the nominating committee have submitted the following names in their place.

President: John T. Gibbons, Brighton High School, Brighton, Mass.

Vice-President: Albert Thorndike, Milton Academy, Milton, Mass.

Executive Committee:

George H. Colman, Gloucester High School, Gloucester, Mass.

James J. Cotter, Chelsea High School, Chelsea, Mass.

Edward Sawin, High School, Cranston, Rhode Island.

Mr. J. Herbert Ward, Classical High School, Providence, Rhode Island, spoke briefly in regard to a request that the Eastern Association of Physics Teachers help sponsor an exhibit of home-made apparatus made by pupils, and at the expense of the Westinghouse Talent Search in cooperation with Science Clubs Incorporated. The matter was postponed for further consideration pending the transmission of further information by Mr. Ward.

A motion was made by one of the members that a small booklet be printed by the Association containing a brief history, the constitution, list of members, etc., similar to the one formerly issued by the Association, but which has not been reprinted for some years. The motion was seconded, and it was voted that the officers be a committee for the revision and printing of the booklet.

HOW FAST SOUND?

MISS ANNA E. HOLMAN, *Winsor School, Boston, Massachusetts*

"How fast sound?" ask the pupils. In some schools the text-book answers, and then an experiment with a pistol and a blank cartridge follows. In other schools the experiment comes first. But, whichever type of school it is, there are times when the stop-watch is out of order, or when there are no firearms in the equipment, and the fact without the experiment is singularly barren.

The following way of determining the velocity of sound is described in a set of Turner-Hersey sheets which I read recently. It happened to be a new method to me and to various people to whom I have spoken. So, since it gives good results without the traditional equipment, I venture to describe it to you.

One observer, A, stands out of doors beside a pendulum with a known period of vibration (say one-half second). He sets the pendulum in motion and makes a sharp noise (say by hitting a board with a hammer) every time that the pendulum completes one oscillation (say when it is at the top of its arc on the right).

Observer B watches the pendulum (with field glasses if necessary) and moves away from it until the sounds of the hammer-blows coincide with the sight of the pendulum passing the point agreed upon.

The distance from A to B then represents the distance which sound has travelled during one oscillation of the pendulum. The distance sound travels in one second is, naturally, the length of AB multiplied by the number of vibrations per second, in this case by two.

This method has some disadvantages. First, it depends on the reactions of two people instead of one. The sound and the light do not start simultaneously as with the starter's pistol, but depend on A's ability to synchronize his blow with what he sees. Second, the period of vibration of the pendulum, though correctly set up indoors, may be appreciably changed by the out-of-doors temperature. Also, echoes, because the effect is a succession of sounds, can be particularly bothersome.

But it has some real advantages. First, simplicity of apparatus. It depends on materials which anybody has and which anybody can use; this board and hammer, this plumb bob, this support, and a measuring tape. No stop-watch is needed and no cartridge. Two, it uses principles from other fields and gives a chance for amalgamation of subject-matter: as, the principle of the pendulum, and meaning of the period of vibration, as well as the effect of temperature on pendulum and measuring tape.

As to its accuracy, for all its rough and readiness the results are surprisingly good. Two of my pupils did it the week after the blizzard, when they were considerably hampered in getting a long distance between A and B. I left it to them to work out. To my dismay I found they had set up a short pendulum of $T = \frac{1}{4}$ second. Also they had put A so near a brick wall that the echoes were very bad. Nevertheless they found AB to be 221 feet, which gave them 1105 ft. per sec. for the velocity of sound. Since the temperature was 32°F., they had an error of about 15 feet, or about 1.3%, and obviously this was done under the worst possible conditions.

From this brief account you can see the technique and the possibilities of this method.

SOME UNUSUAL MAGAZINE ARTICLES

MR. KENNETH L. GODING, *Attleboro High School, Attleboro, Mass.*

For the past three years I have been employed in the research laboratories of the General Plate Division of Metals and Controls at Attleboro, Massachusetts. The General Plate Division is the largest metal plating company in the world. Their plating has to do with ferrous, non-ferrous, and precious metals. Some of the material manufactured is used by the Spencer Divisions of the company in making thermostats, heating controls, circuit breakers, and motor protectors. The heart of some heating control devices is the Klixon or snapping switch. (Klixon and circuit breakers were shown.)

At the plant is a library with a large number of scientific books and many scientific journals. A full-time librarian is employed to help the laboratory staff as well as the workers in the shop to find material related to their work.

As a high school teacher, I have found these magazines most useful in connection with my school work. Yesterday, while at the library, I picked up these magazines as samples to show some of the worth-while articles in them.

Articles shown were:

"Pocket Size Solar Still," *Aero Products*, March, 1945.

"Let's Keep the Climatic Research Laboratory," *Industry*, March, 1945.

"Spinning Magnesium," *Modern Metals*, March, 1945.

"Some Recent Applications of Electronics to Industrial Process Instruments," *Instruments*, March, 1945.

"Electric Arc Welding Helps Make Mass Production of Penicillin Possible," *the Welding Journal*, March, 1945.

"Communication of the World's Greatest Airline," *Radio News*, April, 1945.

"Induction Heating," *Iron Age*, March 22, 1945.
"Republic P47-Thunderbolt," *Industrial Aviation*, Jan. 1945.
"How Does the Protected Motor Behave Upstairs?" *Electrical Manufacturing*, March, 1945.

THE REQUIREMENTS TO TEACH PHYSICS. THE A.A.P.T. REPORT

MR. HOMER W. LESOURD

Mr. LeSourd briefly reviewed the history of the American Association of Physics Teachers and spoke of the stimulating effect of the organization on the teaching of physics at the college level. About seven years ago a committee, sponsored by the organization undertook to investigate High School physics teaching. Later, the scope of the committee's work was expanded to include other fields of science and it is now known as the Co-operative Committee. Its study has disclosed lack of adequate preparation for teaching elementary physics by many teachers of the subject. The Eastern Association of Physics Teachers and other similar organizations have been asked to consider certain proposals aimed to improve this situation. Three of these were presented by Mr. LeSourd, who directed the discussion and the vote which was taken by the members who were present.

The first to be considered was first proposed in 1943 by the U. S. Commissioner of Education, Dr. Studebaker, who asked whether the basic sciences should be included along with vocational education in a federally subsidized program. Mr. Burton L. Cushing, who has been giving ESMWT courses particularly intended for physics teachers led the discussion followed by other members. The consensus of opinion was strongly in favor of such aid in so far as it is needed in connection with the training of science teachers but there was strong opposition to its use in schools because of the threat of governmental interference and dictation.

The second question deals with the recruiting and training of prospective science teachers during their undergraduate course in college. Professor Black, who has for many years been interested in this, presented a rather discouraging report on his own efforts. Few students have any inclination to prepare for secondary school science teaching, largely because of the fact that other careers seem more attractive financially. The vote of the members was indecisive on this question.

The committee report describes at some length a plan for "competency certificates" based on courses taken in college and on an examination prepared by or administered by the examining committee from one or more of the national scientific societies. This plan, in general, met with approval, but with two reservations; that it should not be imposed as a requirement, and that the examination given should be fair and reasonable.

Members who were present seemed to be pleased to have the information regarding the activities of the Cooperative Committee. Further developments will be particularly interesting because of the discussion in the meeting.

FIFTY YEARS AGO

The Early Days of the Eastern Association of Physics Teachers

MR. FRED R. MILLER

I cannot speak at first hand of the Physics Association fifty years ago, as my membership did not begin until 1902, or forty-three years ago. There

are still in the Association a half dozen or so who have been members longer than that. So please do not think of me as the oldest inhabitant.

The best information available to me about the early days is from the printed report of the fiftieth meeting of the Association held May 15, 1908. This meeting consisted of a Saturday morning session at Harvard and a banquet the evening before in Boston. At the banquet the secretary of the Association, who happened to be Mr. LeSourd, brought out a number of facts which he had culled from early correspondence and reports of meetings. The gist of it is as follows:

The idea of a "Science Club" first took form in a meeting of seven men held at the home of John C. Packard at Brookline. These seven men were Packard, an alert, keen, quick-thinking and quick-speaking man of about thirty, a teacher at the Brookline High School; A. B. Kimball of Worcester and later principal of the gold plated high school built for the town of Fairhaven by the Standard Oil Magnate, H. H. Rogers; Charles R. Allen, of the New Bedford High School and later the textile member of the Massachusetts State Board of Education; Frank Rollins of Newton and later of New York City; Charles F. Warner of Cambridge and later principal of the Springfield Technical High School; and either John W. Hutchins, later principal of the Malden High School, or Frank M. Gilley, of Chelsea, author of a unique textbook which, as far as I know, was not used in any school but Chelsea, but which every physics teacher kept on his desk to steal ideas from.

At this meeting a circular letter was drawn up and signed by these seven men, and was mailed to other physics teachers, announcing the first meeting, to be held February 2, 1895 at the Thorndike Hotel. This meeting was attended by eighteen persons, who organized the Association and became its charter members. The officers for the first two years were Packard, President; Allen, Vice-President; Kimball, Secretary; and Warner, Treasurer.

All four of these officers and three other charter members were present and spoke at the banquet of the fiftieth meeting just referred to. Mr. Packard spoke on the significance of the fact that ours was the first association of science teachers organized in this country and probably was the first organization of specialists in any line of teaching. Mr. Allen told how the name happened to be chosen. "It was thought by the founders that, although the membership of the Association was at that time small, its name should be large in order to command respect." He expressed regret that with increased membership (at the time of the 50th meeting, about 75 active and 75 associate) we had lost something of the spirit of comradeship and helpfulness which characterized the early days.

For this reason it was thought desirable to keep the membership small. In fact, joining the Physics Association was a good deal like joining the Masons, you almost had to be invited. At first the number of active members was limited to 50. This was later raised to 75, then to 100, and finally the limit was removed. This limitation probably did have the effect of making the membership more select, and of making teachers more desirous to join. We want what we can't have.

For years women were not admitted to active membership. Probably it was feared that they might get control and try to run things, then what would the men do? There was nothing in the constitution that excluded them, but the Executive Committee always steered them into associate membership. I don't know whether or not they are admitted now. Perhaps I should not let this cat out of the bag.

Teachers of today may not realize what the science instruction of fifty years ago was like. It consisted of textbook work with a few lecture table

demonstrations by the teacher. The first high school physics laboratory in the United States was started in about 1885 in the Boston English High School by A. P. Gage, author of a series of textbooks known as Gage's Physics. This laboratory was a simple affair, but it was a room by itself with tables and stools and a few pieces of apparatus, largely home-made. Because there was little apparatus obtainable, Mr. Gage formed the firm of A. P. Gage and Son and went into the business of designing, making, and importing apparatus, and made a good thing of it.

A little later, around 1890, Harvard College tried to encourage laboratory work by requiring laboratory experiments for entrance in physics. The famous Descriptive List of Experiments, followed by the Hall and Bergin text book based on those experiments, came out in the early 90's. Packard and his friends were alive to the new developments and the Eastern Association of Physics Teachers was the result. In fact one of the requirements for active membership in the organization was that the applicant should be teaching the subject *by the laboratory method.*

The Association took the lead in many ways. Numerous committees were formed from time to time, and their work was never perfunctory. In 1900 one committee compiled a "*List of Reference Books Suitable for Work in Secondary School Physics.*" This was a 27 page pamphlet describing in detail over a hundred books from which the physics teacher could build his professional library. Another committee published a pamphlet on laboratories, with pictures and plans, together with lists of apparatus and information about purchasing and making apparatus. Whenever there was a need the Association went at it.

In the early days no matter where the meeting was held every one went; for when so much was new no one could afford to miss a thing. The long rides on the train were interesting and profitable social affairs, as sometimes half the people on the car were our members. At a meeting in Springfield, Mr. Warner gave a demonstration of the newly discovered liquid air, which he brought personally from New York, after having some difficulty with the police on account of the escaping "fumes." At Hartford there was a largely attended joint meeting with the New York Physics Club, Hartford being about midway between Boston and New York.

From almost the very first until the hook-up with SCHOOL SCIENCE AND MATHEMATICS there were printed reports of the meetings. These reports ran from 15 to 40 pages.

The Association has always had great influence with the colleges and with the College Board. Dean Sabine of Harvard once assured us that whatever we recommended with unanimity the physics department of Harvard would strive to carry out. And we have had similar assurances from time to time from the College Board. When the war is over there will be radical changes in educational procedure, and it will be our duty to take the lead in stabilizing these changes. We should be making preparations now.

ATOM SMASHING AND ITS MODERN APPLICATIONS

Abstract of the Lecture by PROFESSOR ROBLEY D. EVANS

During the war physics has played a great part in scientific research. Optics in bomb-sights, electricity in radar, and all the branches of physics in general have added much new material to knowledge, and the time will come when the value of this research will appear in peacetime uses, rather than in the uses to which unfortunately it has been put.

This new importance of physics will result in new trends at the high school level, and the teacher of physics will become an especially important

member of the teaching profession. The physics department has been greatly overburdened and understaffed. There must be a great improvement to meet the new conditions, for an important destiny and great things are ahead.

One of the standard fields at this time is atom-smashing, not a very old field, as preliminary experiments began about the time of the last war, and in practical outside applications it is only about ten years old. Let us summarize how atoms have become so interesting and useful, for many things of permanent value in a peaceful and useful society have been done.

Reviewing the conditions of matter we find that a glass of water contains a very large number of atoms, about 20×10^{24}. One cannot visualize a number of this magnitude, but if mixed with all the water in the world and the glass were again filled with the mixture there would still be 5000 of the original atoms in the glass. These atoms are of extremely small size, having a diameter of about 10^{-8} cm.

In astronomy scientists think of distances in thousands or millions of light years. In the atom we have the opposite extreme. Man with his approximately six feet of height is near the geometric mean of these two extremes of measurement.

This crystal of zinc sulphide may be used to translate this change of scale. To see the atoms in this crystal it would have to be made large enough to get the earth into the center of the crystal. On this scale, in all directions one could see the structure of the molecule, with its atom of zinc and its atom of sulphur. The zinc atomic structure consists mostly of empty space. Force fields keep the parts of the atoms in their places, and prevent interpenetration of one atom by another. All zinc atoms have 30 electrons, all sulphur atoms, 16. Why? It is a property of the atomic nucleus. The nucleus determines what the atom is going to be. Let us imagine that this crystal expands again until the sun and its planets can be placed within its limits. Then the nucleus will become visible. Its material parts are extremely dense, but most of its volume is empty space.

The simplest of all the atoms is hydrogen. Let this pink sphere represent the nucleus of hydrogen or one proton. Electrically it has a unit charge. Its mass is 1.008, which is unit mass, and to form a neutral atom it must have one electron. If we were in the middle of this atom and the nucleus were magnified to the size of this sphere, the electron, larger than the proton, would be represented by the balloon attached to the door over there, but would be 5 miles away.

Next we have heavy hydrogen. This atom will have 1 proton and another particle, the neutron, with no electrical charge, in the nucleus. The neutron acts as the cement to bind the nucleus together, since, without it, the protons, by their electrical repulsion would tend to push the nucleus apart. One planetary electron completes the neutral atom of hydrogen. This heavy hydrogen is called deuterium and is an isotope. There is another isotope of hydrogen with an atomic weight of 3. Atoms of the same element with different configuration due to different numbers of neutrons are called isotopes.

If the atom has a nucleus composed of 2 protons and 2 neutrons, it is helium in its common variety, and has 2 atomic electrons, which in this scale of magnification would be 5 miles away. Its atomic number is 2 and its atomic weight is 4. The protons and neutrons are similar and are called nucleons, or fundamental nuclear particles. (A charge quantum state of 0 is the neutron, of 1 is the proton.)

All the rest of the elements have different configurations in the nucleus. In oxygen the number of neutrons varies. There may be eight protons and eight neutrons, in which case the atomic weight would be 16, or there may

be 9 neutrons in which case the atomic weight would be 17. There is also a rare isotope with an atomic weight of 18. All three are found in the same proportions in all samples of oxygen.

The heaviest nucleus among the elements is that of uranium, which in its heavy isotope requires 146 neutrons to bring stability to 92 protons.

Professor Evans showed slides among which was a graph in which was plotted all the atomic nuclei of the elements occurring in nature. It is found that there are 270 stable isotopes. Nature, in the beginning tried all available isotopes, but 270 persisted, and the rest disappeared because of their instability. These are represented by blank spaces in the graph. They may be reproduced in the laboratory and produced for study by bombarding the stable ones, thus obtaining other types of nuclei.* This is the whole of atom-smashing.

For example take the nucleus of heavy hydrogen. Deuterium is bombarded with deuterium. Momentum is present. Excess energy is given to a particular particle of the group, which is shot away carrying the excess energy with it. In this way free neutrons can be made. The neutral atom of helium is a stable form of helium of atomic weight 3, found a few years ago. It is a case of synthesis as many atom-smashings are. A particle flies away. Helium and neutrons result.

The equipment used is one of several types, among which are the cyclotron. The one pictured on the slide had a circular tube between the jaws of an electromagnet. The cyclotron chamber was 42″ in diameter having 2 D shaped electrodes, and producing a deuteron beam of 14,000,000 volts. The apparatus is remote controlled from a panel, and screened with more than 4 ft. of water as a barrier.

All the chemical elements have been bombarded with deuterons, alpha particles, neutrons, protons and gamma rays. Transmutation has been achieved in all known chemical elements, and new isotopes made and studied. A number of the gaps in the first slide have been filled, and nearly 400 nuclear species not found in nature have been made.

Radioactivity has been studied. There are five kinds. They are alpha-ray radioactivity, beta-ray with emission of electrons, beta-ray with emission of positrons, electron capture, and isomeric transition.

Artificial radioactivity may be produced in phosphorus which has 15 protons and 16 neutrons. The outer valence electrons control the chemical properties, and are not modified by what is done to the neutrons in the nucleus. When bombarded with deuterons, the deuteron enters the nucleus and sticks there, and then a proton is shot off, carrying with it excess energy. This gives phosphorus with atomic weight 32. This isotope is not stable nor is it found in nature. The nucleus is too heavy, having one too many neutrons. The neutron can change to a proton, but will the resulting nucleus be stable? Is there a stable isotope with 32 for its atomic weight? Sulphur has such an isotope. 15P32 forms 16S32. The nucleus at the same time gives off a beta ray (1 electron). Energy is involved and the new form has a lower energy state and agrees with the conservation laws. The half-time of this radioactive phosphorus is 14 days.

Atoms can be used as tracers. Professor Evans showed how radioactive phosphorus in the form of phosphoric acid could be detected in narcissus blossoms after 3.4 mg. were mixed with water in the vase and allowed to stand 1½ hours. When held near a Geiger counter distinct evidence of having absorbed radioactive phosphorus was shown.

Two simple applications among many that have been made, of the use of

* A copy of the graph mentioned is included together with additional material on the subject in Dr. Evans' paper "Atom Smashing and its Applications to Medicine" in *Electrical Engineering*, June, 1941.

atoms as tracers were mentioned. One was in the study of thyrotoxicosis in humans. After the patient had been given half a milligram of radioactive iodine in water, a Geiger counter was held near the thyroid region, and results of these experiments showed that thyrotoxic cases take up iodine much more rapidly than normal cases.

The other example cited was in the study of the length of time that whole blood could be kept before transfusions, and still be safe to use. Manganese and cobalt were bombarded and changed into radioactive iron. This was made into a citrate and taken into the red cells, which were thus tagged. 500 cc. transfusions of the marked blood were made. It was banked under various conditions of temperature and other factors, and given as transfusions to volunteers. It was thus determined whether or not it stays in circulation.

Similar methods have been used to determine the thickness of the enamel coating on refrigerators in the factory, and the thickness of oil on the rollers in steel mills, and countless other industrial and scientific applications.

ONE WAY OF TEACHING ACCELERATION

Address by the Vice-President, MR. CLARENCE W. LOMBARD

In the next few minutes you will pay the penalty for the mistake you made in electing me Vice-President of your organization this last time. You have escaped the ordeal on two previous occasions, and you should have remembered that "the third time never fails."

The demonstration experiment which I shall attempt to describe represents an effort to make available to boys of the Mechanic Arts Course, tenth grade, a complete understanding of the principles of Uniformly Accelerated Motion in simple terms, and to enable them to solve problems by the use of easy multiplication and not too difficult division.

I will not take the time, here, to enumerate the characteristics of Mechanic Arts classes. If you have met any, you know them all too well. If you haven't, nothing I could say would be convincing. They may be the next generation of the W.P.A.

The demonstration is a modification of Galileo's experiment with the inclined plane. You will notice little change in the method of operation, but, I hope, considerable difference in the use of the data in the solution of problems. I shall make no claim that the idea is original beyond a statement that I have never seen it described, and nobody told me about it.

The home-made apparatus consists of a board eight feet long, and about a foot wide, having four narrow strips, also eight feet long, fastened parallel to each other on one side. There is also a trap or gate at one end. When the board is stood up nearly edgewise, and the end where the gate is, elevated a few inches, the strips form slopes of equal grade. First we roll a ball down one of the hills and note that it starts slowly, gains speed as it descends, and reaches its maximum velocity at the foot. When four balls are released simultaneously it may be observed that they stay abreast of each other all the way down. Finally bumpers are placed on each of the hills and their position adjusted so the balls will "count off" equal intervals of time as each hits its respective bumper. This last operation may be done

with as much, or as little class-participation as may be desired, or as time will allow. Usually, at this point, a lively discussion develops; widely different opinions are expressed, but, to date, no bloodshed can be reported. In any event the results are always the same, and will be shown in a table which will emerge eventually. All distances are expressed in inches.

When the bumpers have been properly arranged and most of the class satisfied, the distance from the gate to the first bumper, from the first to the second, etc., can be measured to discover how far each ball travelled during the last interval of its motion. We find 5, 15, 25, 35. These figures are recorded in the table (line 2, below) and it is also observed that they are in the ratio of 1:3:5:7.

If we find the difference between each of these distances and the one immediately before or after it, we discover that the gain in speed was the same in all cases, and always equal to twice the distance covered in the first interval. It is better, usually, to start with column four and work backward as $35-25=10$; $25-15=10$, etc. If there is any objection to recording 10 as the gain for the first interval, it can be checked for further consideration.

Now we might like to find how fast each ball was going at the end of its trip. Again start in column four and work backwards. Obviously, if the ball gained 10 inches in each interval for four intervals, its final velocity (dictionary word meaning speed) was $10\times4=40$. Also $10\times3=30$; $10\times2=20$; $10\times1=10$. (And the objection noted when the gain for the first interval was recorded has been overcome.)

Measuring the distances from the gate to each of the bumpers will disclose that the total distance travelled by each of the balls was 5; 20; 45; 80, and it may be observed that the ratios are 1:4:9:16. Better record these in the sixth line.

Intervals of time (t)	1	2	3	4	Observations
Distance in each (d_1) etc.	5	15	25	35	Ratio 1:3:5:7; $d_t=d_1(2t-1)$
Gain in speed each (g)	10	10	10	10	Uniform: Always $=2\times d_1$
Velocity at end of each (V_f)	10	20	30	40	$V_f=g\times t$
Av. Velocity for each trip (V_a)	5	10	15	20	$V_a=\frac{1}{2}V_f$
Total distance end each (s)	5	20	45	80	Ratio: 1:4:9:16 $s=V_a\times t=\frac{V_f}{2}\times t=\frac{g\times t}{2}\times t=\frac{1}{2}gt^2$

The average velocity for each trip can be found by dividing its total distance by the number of intervals required to cover it. When these averages are compared with the final velocities in each case it is revealed that the averages are always just half of the finals and the entire table is here.

Let us see how the scheme can be applied to the solution of problems. Observe, and remember that $g=2\times d_1$; $V_f=g\times t$; $V_a=\frac{1}{2}V_f$; $s=V_a\times t$. Obviously, if these values are the results of multiplication, all of the others can be obtained by division. My classes are always asked to "analyze the motion" which involves finding all the answers to d_1; g; t; V_f; V_a; and s. May I offer a few samples?

I. Suppose a ball rolls down an incline gaining at the rate of 10 and stays in motion for six intervals.

Here $g=10$ and $t=6$. So

$$\begin{aligned} d_1&=\tfrac{1}{2}g=5 \\ V_f&=g\times t \quad \text{or} \quad 10\times 6=60 \\ V_a&=\tfrac{1}{2}V_f \quad \text{or} \quad 30 \\ s&=V_a\times t \quad \text{or} \quad 30\times 6=180 \end{aligned}$$

II. A boy on skis gains at the rate of 6 and acquires a velocity of 60 ft./sec. at the foot of the hill.

Here $g=6$; $V_f=60$. So

$$\begin{aligned} d_1&=\tfrac{1}{2}g=3 \\ t&=V_f\div g \quad \text{or} \quad 60\div 6=10 \\ V_a&=\tfrac{1}{2}V_f \quad \text{or} \quad 30 \\ s&=V_a\times t \quad \text{or} \quad 30\times 10=300 \end{aligned}$$

III. A sled coasts 147 ft. in 7 secs. on a uniform grade.

$s=147$; $t=7$. So

$$\begin{aligned} V_a&=s\div t \quad \text{or} \quad 147\div 7=21 \\ V_f&=2\times V_a \quad\quad\quad\quad =42 \\ g&=V_f\div t \quad \text{or} \quad 42\div 7=6 \\ d_1&=\tfrac{1}{2}g=3 \end{aligned}$$

IV. A mason dropped a brick from the 13th floor of a new building. If it fell 16 ft. in the first second and reached the ground in 3 seconds, how high is the 13th floor? What is the distance between the floors?

$d_1=16$; $t=3$. So

$$\begin{aligned} g&=2\times d_1 \quad \text{or} \quad 2\times 16=32 \\ V_f&=g\times t \quad \text{or} \quad 32\times 3=96 \\ V_a&=\tfrac{1}{2}V_f \quad\quad\quad\quad =48 \\ s&=V_a\times t \quad \text{or} \quad 48\times 3=144 \end{aligned}$$

$144\div 12=12$ ft. between floors.

The first floor is level with the ground.

Note: This is the first mention of freely falling bodies but the fact of $d_1=16$; $g=32$ are usually accepted readily.

V. A sled acquired a speed of 60 ft./sec. in 5 seconds down a hill and coasted along a level, stopping in a distance of 240 ft. Analyze the motion (1) on the hill and (2) on the level.

On hill $V_f = 60$; $t = 5$.

$$g = V_f \div t = 12$$
$$d_1 = \tfrac{1}{2}g = 6$$
$$V_a = \tfrac{1}{2}V_f = 30$$
$$s = V_a \times t = 150 \text{ ft.}$$

It may take a bit of time to discover that slowing down on the level is merely the reverse or opposite of speeding up on a hill, and that all the velocity gained on the hill must be expended on the level, and the change in speed is a loss expressed as g.

Then $V_f = 60$; $s = 240$. So

$$V_a = \tfrac{1}{2}V_f = 30 \text{ (same as on the hill)}$$
$$t = s \div V_a = 8$$
$$g = V_f \div t = 7\tfrac{1}{2}$$
$$d_1 = \tfrac{1}{2}g = 3\tfrac{3}{4}$$

VI. A hockey puck struck with sufficient force to give it an initial velocity of 80 ft./sec. slid 320 ft. along the ice.

Here $V_f = 80$; $s = 320$. So

$$V_a = \tfrac{1}{2}V_t = 40$$
$$t = s + V_a = 8$$
$$g = V_f \div t = 10$$
$$d_1 = \tfrac{1}{2}g = 5$$

VII. Same puck on same ice starts with velocity of 40 ft./sec. (Same ice will offer same friction to same puck; so the $g-$ will be the same as in the preceding problem.)

Then $V_f = 40$; $g- = 10$. So

$$V_a = \tfrac{1}{2}V_f = 20$$
$$t = V_f \div g = 4$$
$$s = V_a \times t = 80$$

So the puck which had *one half* the initial speed went only *one fourth* as far as on the first occasion.

These samples should suffice to indicate the possibilities of this very simple method. Since I have been using it I am convinced that the boys have been able to grasp, at least, the fundamentals of a topic with which everybody, in this mechanized age, should be familiar. Interest in this unit is easily sustained, and lasts as long as in any other. Tenth graders prove to be as capable of solving problems as their older brothers in other courses who try to ride to the answers on their "wheel chair" formulae. At the last we drop bombs on Dedham, throw cannon fire on Belmont, and close the study of Accelerated Motion in a blaze of glory.

APPLICATIONS OF LOW FREQUENCY CURRENTS IN THE PRACTICE OF PODIATRY

Abstract of the lecture by DR. HARVEY ATKINSON

Dr. Atkinson first explained the different types of electric currents used in his work. They were, he said, of four or five types, the sinusoidal currents of slow, medium, and rapid, and sustained peak types. There were also galvanic sinusoidal, superimposed sine, and galvanic (direct). These were demonstrated by means of apparatus including an oscillograph.

The slow cycles stimulate muscle tissue, 5 to 20 cycles producing mechanical contraction of muscle tissue. Continued a little longer, they generate heat, and hydrogen ions are liberated in the tissues. Thus, when the cycle changes there are (1) muscle contractions, (2) some heat, and (3) some chemical action.

Applied to muscle cells, the tissue can maintain its normal strength only when the current is properly used. Too prolonged use may weaken and atrophy certain cells.

In the general system it may be used in cases of high blood pressure. It affects the central nervous system somewhat, and causes an increase in the amount of phosphates and urea secreted. The current may be used on any part of the body except near the heart.

With direct current (galvanism), the positive pole does everything differently from the negative pole. The negative pole is a vasodilator, while the positive pole tightens a vein up. This results in a feeling of warmth with the negative pole and a feeling of coolness with the positive.

The age and physical condition of the person treated must be known as well as the purpose of the treatment. The amount of voltage, milliamperage, and length of time must be determined, undertreatment rather than overtreatment always being the rule.

The direct current may be used to drive in certain drugs or to change the circulation under the skin. The positive is acid in reaction, a vasoconstrictor, dries up discharges, hardens scar tissue, reduces inflammation, is soothing, and mildly germicidal. It drives into the tissues metals, bases, caffeine derivatives, and adrenalin, and may be used in cases where these are not better administered by mouth.

The negative pole has an alkaline reaction, is a vasodilator, mildly irritant, and not germicidal. It will liquefy scar tissue, and repels all halogens, acids, and all salicylates. With solutions of copper sulphate, it has been found useful in treating stubborn cases of athlete's foot, which may sometimes be an acid condition.

A NEW PHOTOMETER

Transmission photometer is an electric device that analyzes the composition of metals by reading a photographic plate of the metals' spectrum. It measures the density of the spectrum lines in the spectrograph, thus showing the proportion of alloy in the metal.

SIGNALING BY COLOR

Signaling searchlight, a 12-inch unit used to send colored code messages, is housed in a drum-type casing on a trunnion bracket that pivots on a stationary base. It can withstand the roughest weather and severe repercussion. Nine words per minute can be sent with it.

BOOKS AND PAMPHLETS RECEIVED

THE NEW APPLIED MATHEMATICS, by Sidney J. Lasley, Southeast High School, Kansas City, Missouri, and Myrtle F. Mudd, Northeast Junior High School, Kansas City, Missouri. Third Edition. Cloth. Pages xii+431. 15×23 cm. 1945. Prentice-Hall, Inc., 70 Fifth Avenue, New York, N. Y. Price $2.20.

TEXTBOOK OF ORGANIC CHEMISTRY, by E. Wertheim, Professor of Organic Chemistry in the University of Arkansas. Second Edition. Cloth. Pages xiv+867. 15×23 cm. 1945. The Blakiston Company, 1012 Walnut Street, Philadelphia 5, Pa. Price $4.00.

MATHEMATICS OF FINANCE, by Theodore E. Raiford, Department of Mathematics, University of Michigan. Cloth. Pages viii+176. 15×22.5 cm. 1945. Ginn and Company, Statler Building, Boston, Mass. Price $2.50.

MATHEMATICS OF FINANCE WITH TABLES, by Theodore E. Raiford, Department of Mathematics, University of Michigan. Cloth. Pages viii +176+305. 15×22.5 cm. 1945. Ginn and Company, Statler Building, Boston, Mass. Price $3.60.

ELEMENTS OF PHYSICS, by Robert W. Fuller, Raymond B. Brownlee, and D. Lee Baker. Cloth. Pages x+831+13. 13×19.5 cm. 1944. Allyn and Bacon, 2231 South Park Way, Chicago 16, Ill.

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THE CHEMICAL FORMULARY, by Editor-in-Chief, H. Bennett. Volume VII. Cloth. Pages xxxii+474. 13.5×21.5 cm. 1945. The Chemical Publishing Company, Inc., 234 King Street, Brooklyn, N. Y. Price $6.00.

ENGINEERING PREVIEW, AN INTRODUCTION TO ENGINEERING INCLUDING THE NECESSARY REVIEW OF SCIENCE AND MATHEMATICS, by L. E. Grinter, Harry N. Holmes, H. C. Spencer, Rufus Oldenburger, Charles Harris, R. G. Kloeffler, and V. M. Faires. Cloth. Pages x+581. 15×23.5 cm. 1945. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $4.50.

HOW TO SOLVE IT, A NEW ASPECT OF MATHEMATICAL METHOD, by G. Polya, Stanford University. Cloth. Pages xv+204. 13×19.5 cm. 1945. Princeton University Press, Princeton, N. J. Price $2.50.

THEORY OF FUNCTIONS, by Dr. Konrad Knoff, Professor of Mathematics at the University of Tübingen, and Translated by Frederick Bagemihl, M.A., Instructor in Mathematics at the University of Rochester. Part One: Elements of the General Theory of Analytic Functions. Cloth. Pages vii+146. 10.5×16.5 cm. 1945. Dover Publications, 1780 Broadway, New York 19, N. Y. Price $1.25.

PLANE AND SPHERICAL TRIGONOMETRY, by Frank M. Morgan, Director of Clark School, Hanover, New Hampshire, Formerly Assistant Professor of Mathematics, Dartmouth College. Cloth. Pages v+247+lxxii. 14×21.5 cm. 1945. American Book Company, 88 Lexington Avenue, New York, N. Y. Price $2.50.

PRACTICAL ANATOMY OF THE RABBIT, by The Late B. A. Bensley, Ph.D., Formerly Professor of Zoology in the University of Toronto. Revised and edited by E. Horne Craigie, Ph.D., Associate Professor of Comparative Anatomy and Neurology in the University of Toronto. Seventh Edition. Cloth. Pages x+358. 13×20 cm. 1945. The Blakiston Company, Philadelphia 5, Pa. Price $3.50.

TELEVISION PROGRAMMING AND PRODUCTION, by Richard Hubbell, Production Manager and Television Consultant of Crosley Corporation, Broadcasting Division. Cloth. Pages xii+207. 15×23 cm. 1945. Murry Hill Books, Inc., 232 Madison Avenue, New York 16, N. Y. Price $3.00.

MEN OF MATHEMATICS, by E. T. Bell, Professor of Mathematics, California Institute of Technology. Cloth. Pages xv+xxi+592. 13.5×21 cm. 1937. Dover Publications, 1780 Broadway, New York 19, N. Y. Price $2.75.

ELEMENTARY MATHEMATICS FROM AN ADVANCED STANDPOINT, by Felix Klein. Part I: Arithmetic, Algebra, Analysis. Translated from the Third German Edition by E. R. Hedrick, Professor of Mathematics in the University of California at Los Angeles, and C. A. Noble, Professor of Mathematics in the University of California at Berkeley. Cloth. Pages ix+274. 13.5×21.5 cm. Dover Publications, 1780 Broadway, New York 19, N. Y. Price $3.50.

MULTI-SENSORY AIDS IN THE TEACHING OF MATHEMATICS, Compiled by The Committee on Multi-Sensory Aids of the National Council of Teachers of Mathematics. Eighteenth Yearbook. Cloth. Pages xv+455. 15×23 cm. 1945. Bureau of Publications, Teachers College, Columbia University, 525 West 120th Street, New York 27, N. Y. Price $2.00.

PRINCIPLES OF RADIO, by Keith Kenney, Editor of Electronics, Fellow Institute of Radio Engineers. Fifth Edition. Cloth. Pages viii+534. 13×19.5 cm. 1945. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price $3.50.

APPLIED MATHEMATICS FOR RADIO AND COMMUNICATION ENGINEERS, by Carl E. Smith, B.S., M.S., E.E., Assistant Director, Operational Research Staff of the Chief Signal Officer, War Department. Cloth. Pages x+336. 13×21 cm. 1944. The McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 18, N. Y. Price $3.50.

TURTLES, by Wilfred S. Bronson. Cloth. 63 pages. 16.5×20.5 cm. 1945. Harcourt, Brace and Company, 383 Madison Avenue, New York 17, N. Y. Price $1.75.

WORKBOOK IN ELEMENTARY METEOROLOGY, by Frederick L. Caudle, M.S., State Teachers College, Oshkosh, Wisconsin. Paper. Pages viii+191. 18.5×26.5 cm. 1945. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 18, N. Y. Price $1.24.

WINGS AND THE WEATHER, by A. L. Chapman, Ph.D., Director (On Leave) Bureau of Research in Education by Radio, The University of Texas; Raymond Fletcher, Ph.D., Principal, Jane Addams School, Long Beach, California; and C. C. Maxey, Economic Analyst, Bureau of Reclamation, U. S. Department of Interior. Paper. Pages iv+188. 14×23 cm. 1945. Pitman Publishing Corporation, 2 West 45th Street, New York 19, N. Y.

FRANKLIN DELANO ROOSEVELT, A MEMORIAL, Edited by Donald Porter Geddes. Paper. 294 pages. 10×16 cm. 1945. Pocket Books, Inc., 1230 Sixth Avenue, New York, N. Y.

LABORATORY EXERCISES, BIOLOGY OF PLANTS, by H. L. Dean, Department of Botany, State University of Iowa. Second Edition. Loose-Leaf. 244 pages. 21.5×28 cm. 1944. Wm. C. Brown Company, Dubuque, Iowa. Price $1.75.

ACCREDITED SECONDARY SCHOOLS IN THE UNITED STATES 1944, by Margaret J. S. Carr, Division of Statistics, Office of Education. Bulletin 1944, No. 4. Pages v+198. 14×23 cm. Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. Price 30 cents.

THE SPIRITUAL PROBLEMS OF A TEACHER, Address by Frederick J. Gillis, Ph.D., Assistant Superintendent, Boston Public Schools, Delivered before The Boston Institute for Religious and Social Studies at The American Academy of Arts and Sciences. 16 pages. 15×23 cm. February 6, 1945.

FIRST ANNUAL REPORT OF THE EDUCATIONAL FILM LIBRARY ASSOCIATION. 1943–1944. 72 pages. 15×23 cm. Indiana University, Bloomington, Ind.

OPPORTUNITIES IN RADIO AND ELECTRONICS FOR RETURNING SERVICE MEN, by Brigadier General David Sarnaff, President, Radio Corporation of America. 28 pages. 13×20 cm. 1945. Radio Corporation of America, RCA Building, 30 Rockefeller Plaza, New York 20, N. Y.

BOOKS, PUBLICATIONS, AND PATENTS OF THE BATTELLE MEMORIAL INSTITUTE STAFF, 1929–1944, Compiled by Thelma R. Reinberg, Librarian. 72 pages. 15×23 cm. Battelle Memorial Institute, Columbus, Ohio.

EDUCATION UNDER ENEMY OCCUPATION IN BELGIUM, CHINA, CZECHOSLOVAKIA, FRANCE, GREECE, LUXEMBOURG, NETHERLANDS, NORWAY, POLAND. Bulletin 1945, No. 3. 71 pages. 15×23.5 cm. Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 15 cents.

THREE AMERICAN MICROSCOPE BUILDERS. 77 pages. 14×22.5 cm. 1945. American Optical Company, Scientific Instrument Division, Buffalo, New York, N. Y.

RESEARCH TODAY. 21 pages. 21.5×28 cm. Lilly Research Laboratories, Eli Lilly and Company, Indianapolis 6, Ind.

SEEING IT THROUGH. 56 pages. 15.5×23.5 cm. Bausch and Lomb, Optical Company, Rochester, N. Y.

THE ROCKEFELLER FOUNDATION, A REVIEW FOR 1944, by Raymond B. Fosdick, President of the Foundation. 63 pages. 15×23 cm. The Rockefeller Foundation, 49th Street, New York 20, N. Y.

LABORATORY FOR DEMOCRACY. 44 pages. 15×22 cm. Whitefish Bay, Wisconsin, Public School Bulletin.

When you change address be sure to notify Business Manager Ray C. Soliday, P.O. Box 408, Oak Park, Ill.

BOOK REVIEWS

ENGINEERING PREVIEW, AN INTRODUCTION TO ENGINEERING INCLUDING THE NECESSARY REVIEW OF SCIENCE AND MATHEMATICS, by L. E. Grinter, Ph.D., C.E., *Vice President and Dean of the Graduate School, Illinois Institute of Technology;* Harry N. Holmes, Ph.D., LL.D., *Head of the Severance Chemical Laboratory at Oberlin College;* Henry Cecil Spencer, A.B., M.S., *Chairman of the Department of Technical Drawing, Illinois Institute of Technology;* Rufus Oldenburger, A.B., Ph.D., *Professor of Mathematics, Illinois Institute of Technology;* Charles O. Harris, B.S., D.Sc., *Associate Professor of Mechanics, Illinois Institute of Technology;* Royce G. Kloeffler, B.S., S.M., *Head of the Department of Electrical Engineering at Kansas State College;* Virgil M. Faires, M.S., M.E., *Professor of Mechanical Engineering and Head of the Department of Management Engineering at the A.&M. College of Texas.* Cloth. Pages x+581. 15×23.5 cm. 1945. The Macmillan Company, 60 Fifth Avenue New York, N. Y. Price $4.50.

This book was written for students who think they want to enter the engineering profession. It is suitable for classes in either the last year of the senior high school or the first year of college. The regular high school classes may have covered much of the subject matter here treated in the regular courses in mathematics, physics and chemistry, but here is an opportunity to review the parts most fundamental for future engineering courses. It is an excellent text for returning service men and others who have been away from regular classroom work for several months or even years. Certainly parts will be new to all high school graduates.

The first chapter, consisting of about fifty pages, is a general orientation section, telling the student some of the types of subject matter he will encounter and how to make his study effective. This is followed by three chapters of about a hundred pages each on the essentials of chemistry, technical drawing, and mathematics. Each of the three topics rapidly reviews the fundamentals but soon carries the student into new ideas and ways of thinking. The mathematical theory covers the most essential topics through algebra, logarithms, trigonometry, and conic sections. A shorter chapter on the slide rule follows, then three chapters based on topics from physics treated from an engineer's point of view. They are Light and Electricity, Mechanics, and Thermodynamics. The text closes with the usual tables of logarithms, trigonometric functions, important constants, etc.

This book is to a large extent of a new type, designed to introduce the student to the work in the engineering field. Its proper use should assist in the selection of courses and prevent numerous failures. If used as a last semester text in high schools it should aid many students in discovering their native temperament and fundamental traits for the engineering profession, or the lack of them, and point out the essential preparation for completion of the work. There has long been a serious need for a book of this type to assist students in the transition from high school to college, to help them in the selection of their life work, to provide the proper preparation, and to save time for both students and faculty.

G. W. W.

FUNDAMENTALS OF PHYSICS, by Bowen C. Dees, Ph.D., *Professor of Physics, Mississippi College.* Cloth. Pages ix+486. 13.5×20 cm. 1945. The New Home Library, The Blakiston Company, 1012 Walnut Street, Philadelphia 5, Pa. Price 69 cents.

Judged by ordinary standards here is indeed a strange type of physics text. It was probably written for students of college age who have not had high school work in physics. I think it is safe to predict that in general they will never become physics students without much greater experience and study than is provided by use of this book. The author has given excellent elementary discussions of the phases of the subject covered. He divides the book into two parts: Part One, by far the greater section, covering the *Fundamentals of Physics*, and Part Two, *Physics in Modern Life*. Nearly one-half the entire book deals with mechanics, 183 pages in part one and 38 pages in part two. This leaves only minor sections for each of the remaining important divisions of the subject. Thus heat is given only 20 pages in the first part and steam engines 7 pages in the second; sound and wave motion get 37 pages and 6 pages; light 50 pages and 8 pages; electricity and magnetism 81 pages and 10 pages; modern electricity 34 pages.

The plan is entirely descriptive. Mathematics, the basic language of physics, is almost entirely omitted. In a few cases, as on pages 52 and 53, where an attempt is made to give the student an idea of the range of a gun and the path of a bomb from an airplane, simple trigonometric equations are given but there is no explanation of the development. A comparatively few diagrams appear, 205 as numbered, but they are merely Fig. 46 or Fig. 110. No legend is given to indicate what they represent and very little is told about many of them in the discussion. No questions or problems occur to disturb the student's thought (i.e. his thought of the next ball game or date). The author has steered very clear of practically all numerical ideas, but some errors among these few are noticeable. On page 14 we find, "1,609 kilometers = 1 mile"; on page 17, "100 cubic millimeters = 1 cubic centimeter." On page 15 the constant π is stated as equal to 3.1416; nothing is said about accuracy. Why not say π is approximately equal to 3, which will give results about as accurate as much of the discussion seems to demand; or $\pi = 3.14$, which is much more accurate than most physics measurements in the first course? Many excellent discussions of appratus and methods are indicated but few of them go far enough to satisfy a real live physics student. To make the subject practical a *student* needs more. The price of the book is only 69 cents. How can any author afford to write a college text-book to sell at this price? The price may really be high for a good student who wants to know physics and has no other tool.

G. W. W.

SCIENCE YEAR BOOK OF 1945, edited by John D. Ratcliff. Cloth. Pages xxviii+224. 14×20 cm. 1945. Doubleday, Doran and Company, 14 West 49th Street, New York 20, N. Y. Price $2.50.

This is the fourth of a series of Year Books built by reprinting articles from some of the most important magazines of the country. The editor gives a rather extensive introduction, eighteen pages, in which he discusses a number of scientific topics not mentioned in the text. Four major divisions are listed: medicine, physics and chemistry, aviation, other sciences. Five of the ten chapters on medicine come from *Collier's*, one each from *Time*, *Hygeia* and *Reader's Digest*, *Cosmopolitan*, *Hygeia*, and one from the book, *How Never to be Tired*, by Marie Beynon Ray. Eight different magazines supplied the material for the nine chapters from physics and chemistry, four for the five chapters on aviation. Two magazines furnish the four articles in Part IV.

Most of these articles are excellent selections and give the reader the

latest information on the development of science. The articles on penicillin, blood transfusion, the use of tantalum in surgery, the electron in industry and medicine, DDT, giant planes, rocket ships, and petroleum should be read by practically all. The last two articles in the book taken from the *Saturday Evening Post* contain so much questionable and hypothetical material that they scarcely merit a place in a book of this type. Certainly the one "When the Comet Struck" should not be read unless the thought is tempered by reading Johnson's book *The Origin of the Carolina Bays.*

G. W. W.

ROCKETS AND JETS, by Herbert S. Zim. Cloth. Pages x+326. 14×21.5 cm. 1945. Harcourt, Brace and Company, 383 Madison Avenue, New York 17, N. Y. Price $3.00.

In the opening sentence of the Foreword to this book the author says: "The difficulty in telling the story of rockets and jet propulsion is that the past abounds in meager reports of secret experiments; the present is cloaked in military secrecy; and the future is an area of vague speculation." But in spite of these difficulties he has given us a splendid little book on a topic of vital importance in the war and later in peace, that can be read and understood by all. The short range effects of the tank destroying bazookas that have frequently saved our armies are well discussed, and both the V-1 robot bombs and the V-2 rockets, that so nearly effaced London, are given as complete descriptions as conditions permit. The text gives a fairly complete discussion of all the various types of rockets now in use or that have been proposed, the types of fuels, and the mechanism of propulsion, with comments and criticisms on each. Three chapters discuss the question of interplanetary rockets. The book contains many illustrations, both photographs and diagrams, and the language is selected for the general reader. The book will appeal to boys who have no interest in the ordinary story usually assigned by many English teachers.

G. W. W.

APPLIED MATHEMATICS FOR TECHNICAL STUDENTS, by Murlan S. Corrington; *formerly of Rochester Athenaeum and Mechanics Institute, now Radio Engineer, Advanced Development Division, Radio Corporation of America, RCA Victor Division.* Cloth. 14×21 cm. Pages ix+226. 1943. First Edition. Harper & Brothers, 49 E. 3rd St., N. Y. Price $2.20.

This book was written for trade schools, pre-engineering students and for the mechanic or engineer as a home study reference. It is a book that all teachers of mathematics in high school and college should have available. It might also be used as a text on the senior level in a technical high school. It provides a source book of applications in industry on all levels of mathematics up to and including trigonometry. The drawings are plates and are labeled true to engineering practices with all information given regardless of the need for that particular problem; this it seems, makes the problem more nearly a life like situation.

A book of this type must use many unfamiliar terms and it should have a glossary covering them, to make the book more meaningful. There is also a need for tables which are mentioned but do not appear in the reviewer's copy. A good deal of emphasis has been placed on developing new processes step by step and good study suggestions are given. The book assumes little knowledge of mathematics but moves too fast for those without such a background or a high ability on the subject. The chapter on logarithms

includes natural logarithms and gives some excellent real life problems using exponential equations. The imaginary is introduced as i with no mention of the use of j which will be more common to the electrician who will use this part of the text. Radian measure has a number of good exercises but they are in such close connection with the degree most people will fail to realize the advantage of the use of radian. Continuity of mathematics is stressed in several places.

Answers are provided to the odd numbered problems and the book is well indexed. The problems vary in difficulty from those easily done by the 8th grade pupil to those extremely difficult for the adult. The author has an error on page 4 concerning the order of operations when multiplication and division are involved; it reads, "multiplication should be performed first then division." I believe it should read, "multiplication and division should be performed first in the order in which they appear." This book will appeal to many students in high school and college because it applies that mathematics they have developed theory for, to the different phases of industry.

PHILIP PEAK

ELEMENTARY ALGEBRA, by Edward I. Edgerton, *William L. Dickson High School, Jersey City, New Jersey;* Perry A. Carpenter, *West High School, Rochester, New York.* Cloth. Pages xlii+522+4. 12.5×19 cm. 1945. Allyn and Bacon, 50 Beacon Street, Boston, Mass.

The authors say that their new edition "has a two-fold aim to give thorough preparation for future work in mathematics and to make the subject a challenging, fascinating intellectual adventure." They also emphasize the practical values of algebra in modern society. The text is basically a treatment of equations: Part I. Through Simple Equations, Part II. Through Quadratic Equations, Part III. Through Numerical Trigonometry.

In Part I they include formulas, and the fundamental operations as well as simple equations, and in Part II, products and factors, functional equations, linear equations, graphs, powers, roots, and quadratic equations. Part III contains ratio and proportion, variation, dependence, numerical trigonometry and aerial navigation.

The text impresses the reviewer as being carefully organized with material of well graded difficulty, and rich in the abundant practice material. Rules are unambiguous and plentiful. Interesting pictures are inserted, yet are not used as problem material but largely for general atmosphere.

Meaningfulness is left largely for the teacher to supply, although significant developmental approaches to new principles are usually given. The problems are the traditional types although clearly stated. A few border on unreality, e.g. "A ladder 30 feet long is set up against a building so that it makes an angle of 72°18′ with the ground. How far is its foot from the building? P. 442. It is doubtful that anyone would measure this angle to minutes to find how far the foot of the ladder is from the building. Until algebras can be made without such unreal problems, mathematics will have a hard time establishing its vital value for the progress of civilization.

Graphs are functionally treated by being used as they contribute to the development of the various subjects. The thought and principles of dependence and functionality are almost omitted. Yet there is opportunity for the well trained teacher to apply dependence throughout the text.

The chapter on aerial navigation contains interesting material, yet much would be gained by using the standard terminology for wind and course

directions. Wind directions are now given as "wind from 300°" not "the wind blows in a direction S 40° E," p. 469. The course of a plane is 198° not "S 18° W." The newer form is much simpler and easier.

In general, the new book is a thorough, conservative, traditional algebra with some new features and an abundance of formal practice materials.

H. C. CHRISTOFFERSON

INTERMEDIATE ALGEBRA, by Edward I. Edgerton, *William L. Dickson High School, Jersey City, New Jersey;* Perry A. Carpenter, *West High School, Rochester, New York.* Cloth. Pages vi+508. 12.5×19 cm. 1945. Allyn and Bacon, 50 Beacon Street, Boston, Mass.

"*Intermediate Algebra* is intended to follow the authors' *Elementary Algebra*, but it may be used after any good first year text." The first three chapters, nearly 100 pages, are devoted largely to review, although a considerable amount of new advanced material is brought in, as for example, the factoring of the sum or difference of odd powers and the factor theorem with synthetic division. Each new chapter begins with review of background work, then adds advanced material.

According to the authors the leading features of the book are, (1) simple, logical development, (2) varied graphic material, (3) numerous and varied verbal problems, (4) carefully graded exercises, (5) frequent reviews and tests, (6) special attention to the formula and function concept, (7) use of slide rule. The text covers, in addition to review and extension of elementary algebra, imaginaries and complex numbers, quadratics by formula, series, binominal theorem, logarithms, trigonometry (20 pages, right triangle only) and a chapter on supplementary topics which includes proportions, permutations, and a glance at analytics and calculus.

In general the reviewer feels that the book is a well organized, thorough treatment of formal algebra with an abundance of practice material. There are no radical features, and little stress on meanings and pupil understanding. There is an abundance of rules, and formal techniques such as transposition. The problems are the traditional kinds that deal with A and B working poor C, Jones and Brown digging the same ditch in different numbers of days, ages of Mary and John, coins, "carriages," rowing boats at remarkable rates, and numbers in complex relationships. The text should serve well for a teacher who wants a thorough course in formal, traditional algebra based upon an abundance of practice with well graded materials, and who is content with looking at the date of copyright to find that it was published in 1945.

H. C. CHRISTOFFERSON

TURTLES, by Wilfred S. Bronson Cloth. 63 pages. 16.5×20.5 cm. 1945. Harcourt, Brace and Company, 383 Madison Avenue, New York 17, N. Y. Price $1.75.

This is a book for the little folk, written by a naturalist and artist who knows both how to entertain children and how to teach natural science. It is highly illustrated with pictures on every page, and is printed in large type. Each sentence gives a new and interesting fact, but the illustrations tell more than the type. Curious facts are told about the great turtles that live in the South American waters and about the small pond turtles that can be kept in the little aquarium. Every child will like this book. We need many more of this class.

G. W. W.

CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS BOARD OF DIRECTORS MEETING, MAY 12, 1945

President Carnahan called the meeting to order in the Stevens Hotel in Chicago at 9:30 A.M. President Carnahan reported that speakers for the general meetings had all been secured and stated that *AUGUST 15th is the DEADLINE* for program details. All speakers are urged to prepare papers and have them ready before the November meeting date. Mr. Carnahan talked of the possibility of not being permitted to hold more than a local meeting in Chicago and that being the case the possibility of having a number of local meetings—Indianapolis, Cleveland, etc.—at each of which would be read the papers prepared by the speakers engaged for the general programs.

Mr. Haggard, the local arrangements chairman, reported that blackboards, screens and other needed materials should be requested before the date of the meeting in order that his committee may anticipate meeting the requests.

The section chairmen present reported on the plans made for their various section meetings. Early in the fall, through the Yearbook or other medium, a full description of the program will be given.

Mr. Trump moved, Mr. Johnson seconded and it was passed that: The Executive Committee proceed with plans for a 1945 convention; that the Executive Committee be advised to apply for privilege of a convention, application to be made at a time which seems appropriate to committee; and that Executive Committee use its discretion as to any alternate procedures to be followed.

Mr. Hawkins moved, Mr. Park seconded and it was passed that: the Business Manager put up to $1000 of Association funds in coupon United States War Bonds.

The above motion was made on the recommendation of the business manager, Captain Soliday, who in his report to the board of directors showed that the business of the association is in good hands. He reported income July 1, 1944 to May 1, 1945 of $9101.66 and expenditures of $8064.95, cash on hand of $4589.94 and current membership of 870, the highest it has been for at least four years. Total subscriptions May 1, 1945, 2872, represent an increase of 195 over 1944. Membership in Chicago has shown a decrease. Captain Soliday spoke of the advantage of mailing a yearbook to every journal subscriber.

Mr. Trump moved, Mr. Johnson seconded and it was passed that: The report of the business manager be accepted.

Mr. Hawkins moved, Mr. Park seconded and it was passed that: The Business Manager will mail a yearbook to each subscriber of the journal at Association expense.

Mr. Peterson, chairman of the Journal Committee, submitted a mimeographed budget proposal which estimated Association receipts for 1945–46 to be $10,290 and expenditures $10,290. The budget report is quite detailed and goes into every aspect of association business. A copy is in the hands of each board member and in the official file of minutes. The secretary will furnish detail to any member on request. Mr. Peterson's report was accepted with only a couple of minor changes recommended.

Mr. Carnahan moved, Mr. Hawkins seconded and it was passed that: Mrs. Geraldine Reep Johnson be the new Yearbook Manager.

Mrs. Johnson reported that advertisers are now applying for space in the yearbook and at the convention. A discussion ensued which went into the various aspects of printing and distributing yearbooks. Any association

member who wishes yearbooks to be sent to any individual or institution should communicate with Mrs. Johnson.

Mr. Leonhard, chairman of the membership committee, reported that he had written to many teachers in all fields of science and mathematics. State Chairmen have been assigned in all states except Wisconsin. The state chairmen in addition to other responsibilities are urged to announce Association meetings in their own state meetings and to get helpers in geographical centers within their own states.

Miss Grant reported that she had fulfilled the request of President Carnahan and had assigned Friends of the Land gift memberships to DePaul University, University of Wisconsin High School, George Washington High School in Indianapolis, John Marshall High School in Cleveland and the Oak Park, River Forest Township High School.

Mr. Haggard recommended the change in name from good fellowship committee to information committee. This met with the approval of the board. He indicated that committee members would have badges. Typists will be at the registration desk to assist the membership committee which will be working in shifts.

Mr. Warner, editor of the journal, stated that Mr. Joseph Dickman would review science films. Elementary and intermediate science material does not come to the journal in great enough quantity. Members of the association who are doing writing in any of the science or mathematics fields are invited to submit such papers to the editor.

Mr. Johnson moved, Mr. Dickman seconded and it was passed that each section be allowed up to $5 for transportation of children brought to the convention for the purpose of class demonstration.

Captain Soliday, in discussing the convention guest fee which has been fifty cents, stated that aggressive action of the membership committee influences many to become association members at $2.50. Further discussion indicated that the board feels that our association contributes service to the teaching of science and mathematics in proportion to the amount of teacher participation, whatever the basis.

Mr. Hawkins moved, Mr. Park seconded and it was passed that the guest fee remain at fifty cents for the present year.

The matter of an honorarium for the membership committee chairman was discussed and it was pointed out that the job was of a more permanent nature than many of the other association jobs and that it was more demanding of energy and time. Mr. Trump stated that one excuse for an honorarium would be to encourage tenure.

Mr. Soliday moved, Mr. Mayfield seconded and it was passed that the membership chairman be paid an honorarium of $50 in recognition of a year of service.

Mr. Johnson moved, Mr. Dickman seconded and it was passed that the budget for 1945–46 be accepted with the minor changes which had been recommended.

The report of the committee to study the matter of sectional meetings at the time of the annual convention of the association submitted a written report.

Mr. Mayfield moved, Mr. Trump seconded and it was passed that a streamlined statement of the report be published in the October Journal, that interested parties be invited to attend the board meeting at the convention and take part in the discussion of the issue and that the disposition of the report be decided at that time. The streamlined version of the report follows and is included in the minutes which will be published in the October Journal.

Procedure: The committee contacted a considerable number of persons

active in association affairs and asked each his opinion and recommendations regarding the continuance of or discontinuance of sections. This report results from the reactions received and from the experience of the committee members in association affairs.

Friday afternoon session. We recommend that no new sections be formed to meet on Friday afternoon, that the elementary science section and geography section no longer meet on Friday afternoon, and that all other sections remain as they now exist.

Only 14 members listed in the 1944 Year Book gave elementary science as their teaching field and therefore the program of the section was planned primarily as a service to paying visitors. This worth-while project can be continued by combining the program with that of the elementary school group on Saturday morning. On Friday afternoon, elementary teachers may attend the general science or elementary mathematics section.

Only ten members listed geography as their subject in the 1944 Yearbook. This small number of members hardly justifies a program on Friday afternoon in competition with other sectional meetings. If these ten members plan a program so outstanding that it draws a group of the membership to it, they are taking these members from other sections which deserve their support. Recognition could be given the members interested in geography on Saturday morning.

We do not recommend the addition of any new sections dealing with aeronautics or economic statistics at this time. The committee feels that these timely topics can be included in the programs of sections already established.

Saturday morning session: We recommend that the number of group meetings on Saturday morning be reduced from five to four, that the programs of these four groups be outstanding, and that the Saturday morning meetings receive more advanced publicity so that the entire Saturday morning meeting will be strengthened.

The committee recommends that the elementary science section from Friday afternoon be combined with the elementary school group meeting on Saturday morning with the title of elementary science group or section. Elementary mathematics is well taken care of on Friday afternoon and does not need a place on Saturday morning. This elementary science group should have an outstanding program and be well publicized and should be one of the features on Saturday morning.

Again, to strengthen the Saturday morning program and extend more courtesy to persons asked to address the groups, we recommend that the junior high school and senior high school groups be combined on Saturday morning. It has been embarrassing to speakers asked to address the junior high school group in recent years because their audiences were so small. Here again, a strong program for one high school group will be more likely to hold a crowd over for the Saturday morning meeting than two programs of less importance.

We recommend that the junior college group be continued with the possible change that it be made the junior college and adult education group.

One more possible combination is that of the geography section with the conservation section for a meeting on Saturday morning.

Most of the persons contacted for suggestions said that a stronger program should be planned for Saturday morning and that these programs should receive more advance publicity. One person suggested that the Saturday morning program needs more glamour and one suggested a Saturday noon luncheon program.

In conclusion, you will note that we have recommended that the num-

ber of sectional meetings of Friday be reduced from 8 to 6 and that the number of Saturday morning groups be reduced from 5 to 4. We feel that these changes will make it possible to adequately house the meetings and provide more satisfactory attendance at each.

The committee recognizes the fact that certain constitutional changes may be necessary to carry out these recommendations and will proceed with the details of such changes if the Board of Directory deems it wise to to accept our proposals.

Respectfully submitted,
CECILIA LAUBY
JOSEPH E. DICKMAN
MARIE S. WILCOX, *Chairman*

Nathan A. Neal, secretary of the National Science Teachers Association, wrote to President Carnahan asking for the privilege of mailing to the members of the Central Association of Science and Mathematics Teachers a report of a committee study entitled, The Place of Science in the Education of the Consumer.

Mr. Trump moved, Mr. Soliday seconded and it was passed that the yearbook be made available to Mr. Neal for mailing the reports.

Mr. Soliday suggested that the Association give some thought to the granting of life memberships in the Association to retiring teachers who have been members of our association for years.

Mr. Schreiber, the historian of the Association, discussed possible plans for celebrating the 50th anniversary of the Association which will come in 1950. Two types of publications may be decided upon, a scholarly publication including a 50 year index to SCHOOL SCIENCE AND MATHEMATICS and a popular publication with the best in current mathematics and science instruction points of view. The secretary suggests that the Board might start a sinking fund to help finance the 1950 anniversary.

The by-laws state that members must be elected to the Association. President Carnahan expressed the point of view that the members should be elected or the by-laws changed.

Mr. Mayfield moved, Miss Grant seconded and it was passed that the secretary have the minutes printed in the Journal.

Mr. Trump moved, Mr. Dickman seconded and it was passed that the editor of the Journal, the business manager, the yearbook editor, the historian and the chairman of the general membership committee be invited to attend board of directors meetings in an ex-officio capacity.

Mr. Leonhard moved, Mr. Johnson seconded and it was passed that the above mentioned officers of the Association participate with directors on a pro-rata basis in the fund set aside for distribution for coach rail fare to and from spring board meeting. ($75 total.)

A ballot sent to the Board of Directors members on March 15, 1945 had the following unanimous result:

New members of journal committee
George Peterson, chairman
Ray Agren
Elementary science section secretary
Illa Podendorf

As these minutes are being prepared for mailing on August 9, 1945, President Carnahan reports that the program is complete with the exception of a section or two. President Carnahan is meeting with the ODT and soon will know what kind or kinds of meetings may be held in November.

Is there a possibility that recent war developments will make a difference? President Carnahan will have all yearbook materials in the printer's hands in about two weeks and will have something in the October and November Journals about convention plans.

Miss Ada Weckel, long an active member and officer of the Association, died on July 10th. Her death closes an active career in the field of science teaching and is a great loss to the Association and the community which she served so many years.

Respectfully submitted,
HAROLD H. METCALF, *Secretary*

POLAND WILL BECOME MORE IMPORTANT AS MANUFACTURING NATION

Germany's territorial loss, under the Potsdam agreement, of Upper and Lower Silesia with their great coal and iron resources, is a great blow to her industrial standing, but their possession by Poland will greatly increase the importance of that nation in the manufacturing field.

The agreement shifts Poland to the west, and in the territorial changes Poland comes out with less acreage, but with gains in natural resources, seacoast, shipping ports, and control of navigable rivers. Only time will tell whether or not her economic gains fully balance her land losses.

The western boundary of Poland, according to reports, will be the Oder river in the north, and a line to the Czechoslovakian border extending from the great bend in the river south of Frankfurt. The area coming to Poland includes the eastern part of Pomerania province in Prussia, most of Lower and all of Upper Silesia. The Silesias were once a part of Poland. They were lost in the eighteenth-century Polish partitions, but still have a large population of Polish people, particularly in the rural areas.

Silesia is an area some 200 miles in length from northwest to southeast, and from 50 to 75 miles wide, projecting between prewar Poland and Czechoslovakia. It is a region of mountains, hills and fertile valleys, with the upper Oder running down its center. The area of the former German Silesia was approximately 14,000 square miles, nearly twice the size of New Jersey. In addition to coal and iron, it produced oil, timber, textile fibers, food crops, cattle, sheep and wool.

The area of Pomerania east of the Oder is about the size of New Jersey and has similar physical characteristics. It is flat, with a range of low hills, and has, in general, a thin sandy soil, numerous lakes, and some timber. It produces potatoes, rye, oats, sheep, cattle, hogs and geese. It contains important former German ports on the Baltic.

In addition to the above acquisitions, Poland will acquire much of East Prussia, and the former Free City of Danzig, the great port near the mouth of the navigable Vistula river which can now furnish water transportation from great inland areas of Poland to the Baltic sea. These acquisitions widen the so-called Polish corridor to the Baltic from a 60-mile prewar strip to a Baltic seacoast about four times as great.

The area that Poland loses to the Soviet Union, roughly 60,000 square miles, is considerably greater than the area gained from Germany. It is practically the area east of the so-called Curzon line, which extends from the southern extremity of Lithuania to Czechoslovakia. This is largely an agricultural and grazing area, but includes a considerable part of the Pripet marshes. A large proportion of its prewar population were White Russians and Ukrainians.

HARRY WILLIAM MOUNTCASTLE RETIRES

Harry William Mountcastle retired in June as head of the department of Physics and Astronomy at Western Reserve University after 38 years of service with that Cleveland institution.

Born in Pittsburgh, Pa., in 1875, he reached retirement age last February 5.

Professor Mountcastle is known in the scientific world chiefly for his achievement in research into the propagation of electromagnetic waves along wires, the thermal conductivity of glass, the magnetic rotatory dispersion of sodium vapor, high frequency oscillations and the optical behavior of metals. He made important contributions to the science of transmitting electrical waves over wires while employed as a physicist by the American Telephone and Telegraph Co. before coming to Western Reserve in 1907.

His work at Western Reserve University has also gained him a wide reputation as a teacher, elucidating the difficult problems of Physics and Astronomy to thousands of students. He made physics important both as a science and as a cultural subject. During the first World War he was active in government service and during the present World War has devoted himself to the instruction of air crew students and technical students in the subjects of aviation and radio.

NEW SPENCER POLARIZING MICROSCOPE

Research scientists working on Spencer instruments have developed a new polarizing microscope. The optical system of this instrument contains Polaroid material in place of the usual calcite polarizing prisms.

The optical characteristics have been found to parallel closely those of calcite equipment. The sensitivity of the extinction point compares favorably with calcite, and there is remarkable freedom from residual color. The shorter length of the polarizing unit and the elimination of several glass-air surfaces reduces the amount of stray light, resulting in a noticeable increase in contrast in the image. This improvement is particularly important in obtaining the maximum brilliance for interference figure work.

The heavy stand, built for critical work, is so adaptable that it will satisfy most of the requirements of the petrographer, geologist, mineralogist, biologist and chemical microscopist.

The new Spencer Polarizing Microscope, No. 42 with available accessories, will meet the requirements of most polarized light microscopy. It is particularly adapted to the needs of the industrial laboratory and is also admirably suited as a teaching instrument.

A bulletin (M136) will be sent upon request.

This new instrument is manufactured by the American Optical Company, Scientific Instrument Division, Buffalo, New York.

A definition is not something to be learned. It is to be understood. . . . The best test of one's understanding is ability to use the definition in the solution of problems. . . . The solution of many numerical problems is an essential part of any course in physics. No definition, principle or relation is fully understood until it can be used for this purpose.

A. A. KNOWLTON, *Physics for College Students*